TRANSACTIONS AND PROCEEDINGS

OF THE

BOTANICAL SOCIETY OF EDINBURGH.

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Vol.33

TRANSACTIONS AND PROCEEDINGS

OF THE

BOTANICAL SOCIETY OF EDINBURGH.

VOLUME XXXIII.

INCLUDING SESSIONS CIV–CVII.
(1939–1943.)

WITH 4 PLATES AND OTHER ILLUSTRATIONS.

EDINBURGH:
PRINTED FOR THE BOTANICAL SOCIETY.
1943.

Printed in Great Britain by
Neill & Co., Ltd., Edinburgh.

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TRANSACTIONS

OF THE

BOTANICAL SOCIETY OF EDINBURGH

SESSION CIV

AN INVESTIGATION INTO THE LEAF AND FLOWER STRUCTURE OF *Rhododendron Griersonianum* Balf. f. et Forrest, *Rhododendron Dalhousiae* Hook. f., AND THEIR HYBRID *Rhododendron Grierdal*.

By ELSPETH J. WATERSTON, B.Sc.

(Read 15th June 1939.)

The division of the genus Rhododendron into lepidote and elepidote species is based on one criterion—the presence or absence of scales. As the scale is of prime importance in the classification of the groups its occurrence on an elepidote-lepidote hybrid is of considerable interest. The formation of such a hybrid is accomplished with difficulty and, with one exception, those in existence are all elepidote. The exception was obtained from the cross *Rh. Griersonianum–Rh. Dalhousiae* by Walker-Heneage-Vivian, and recorded as *Rh. Grierdal* in 1938. In order to establish the authenticity of this unique hybrid the following investigation was carried out on the anatomy of the leaf and flower in the three Rhododendrons concerned.

A shrub of *Rh. Grierdal* was obtained by the Edinburgh Royal Botanic Garden in 1938 and flowered for the first time in 1939.

The parent species are represented by a fine bush of *Rh. Griersonianum* in cultivation since 1918 and a beautiful specimen of *Rh. Dalhousiae* established in 1912.

All three Rhododendrons are growing under similar conditions in the same greenhouse.

Leaves were collected in July 1938 and preserved in Bles solution for hand-sectioning. Narrow strips cut from the centre of the leaf were fixed in chromo-acetic acid and embedded in paraffin wax. Microtome sections 10 μ in thickness were cut and mounted with egg-albumen. Various stains were employed: Bismarck brown, gentian violet and Bismarck brown, diamond fuchsin, and iodine green. Hand-sections were stained in safranin and haematoxylin.

Growth buds were collected in January 1939, fixed in chromo-acetic acid, and embedded.

Epidermal preparations were obtained by two methods: (1) the upper epidermis was treated with Newskin; (2) the lower epidermis was removed by boiling the leaves in caustic soda solution. The latter preparations were stained in Bismarck brown and mounted in balsam.

Unstained hairs and scales were mounted for examination in clear glycerine jelly; glandular setae, obtained from the petioles of *Rh. Griersonianum* and *Rh. Dalhousiae*, were cleared in xylol and mounted in balsam.

Comparison of Characters.

The characters of the three Rhododendrons examined have been tabulated in the following five tables, those of *Grierdal* being printed in roman type when agreeing with *Griersonianum*, and in italics when in agreement with *Dalhousiae*:—

Table I.—External Morphology of the Leaf Blade.

Character.	Rh. Griersonianum.	*Rh. Dalhousiae.*	Rh. Grierdal.
1. Base	Narrowly cuneate	*Cuneate*	*Cuneate*
2. Apex	Acute	*Obtuse*	Acute
3. Margin	Revolute	*Plane*	Revolute
4. Surface	Flat	*Undulant*	*Undulant*
5. Colour of:			
(*a*) Upper surface	Dull green	*Glossy green*	Dull green
(*b*) Lower surface	Buff	*Pale translucent green*	*Pale translucent green*
6. Primary veins:			
(*a*) Number	12–17 pairs	10–12 *pairs*	10–12 *pairs*
(*b*) Visibility	Concealed by tomentum	*Not concealed*	*Not concealed*
7. Indumentum	Dendriform hairs	*Scales*	Hairs + *scales*

TABLE II.—EXTERNAL MORPHOLOGY OF THE PETIOLE.

Character.	Rh. Griersonianum.	*Rh. Dalhousiae.*	Rh. Grierdal.
1. T.S. petiole	Plano-convex	*Elliptical*	Plano-convex
2. Colour	Maroon	*Green*	1. Upper surface maroon 2. *Lower surface green*
3. Grooved upper surface	Grooved	*Not grooved*	Grooved
4. Indumentum	Dendriform hairs + glandular setae	*Scales + glandular setae*	Dendriform hairs + *scales*

TABLE III.—INTERNAL STRUCTURE OF THE LEAF BLADE.

Character.	Rh. Griersonianum. (Fig. 1.)	*Rh. Dalhousiae.* (Fig. 2.)	Rh. Grierdal. (Fig. 3.)
1. Cuticle:			
(*a*) Surface	Verrucose	*Papillate*	*Papillate*
(*b*) Depth	4 μ	1 μ	1 μ
2. Epidermal cells	Biconvex	*Convex-concave*	Biconvex, also *Convex-concave*
3. Hypodermal cells	Concave-convex	*Biconvex*	Concave-convex, also *biconvex*
4. Palisade	Double	*Triple*	Double
5. Lower epidermal cells	Non-papillate	(a) *Papillate* (b) *Papillae long*	(a) *Papillate* (*b*) Papillae short *intermediate*
6. Stomata	Unmodified	*Modified*	Unmodified
7. Crystal frequency	+	+ + +	+ +
8. Venation:			
(*a*) Sclerenchyma sheath	No sheath	*Sheath*	*Sheath*
(*b*) Sclerenchyma mass	Triangular	*Rectangular*	*Rectangular*
(*c*) Subsidiary veins	No sheath	*Sheath*	No sheath
9. Prefoliation	Revolute	*Involute*	*Involute*
10. Conoid hairs (on bud-leaves only)	Conoid hairs	*No conoid hairs*	Conoid hairs

TABLE IV.—INFLORESCENCE.

Character.	Rh. Griersonianum.	*Rh. Dalhousiae.*	Rh. Grierdal.
1. Peduncle	Heavily tomented	*Glabrous*	Sparsely tomented, *intermediate*
2. Pedicel:			
(*a*) Length	3·0–4·0 cm.	1·0–1·5 *cm.*	3·0–4·0 cm.
(*b*) Appearance	Straight	*Curved*	Straight
(*c*) Colour	Red	*Green*	Red
(*d*) Indumentum	Dendriform hairs	*Scales + unicellular hairs*	*Scales + unicellular hairs*
3. Truss	4–5 flowered	2–3 *flowered*	4–5 flowered
4. Position of flower	Erect	*Pendulous*	*Pendulous*

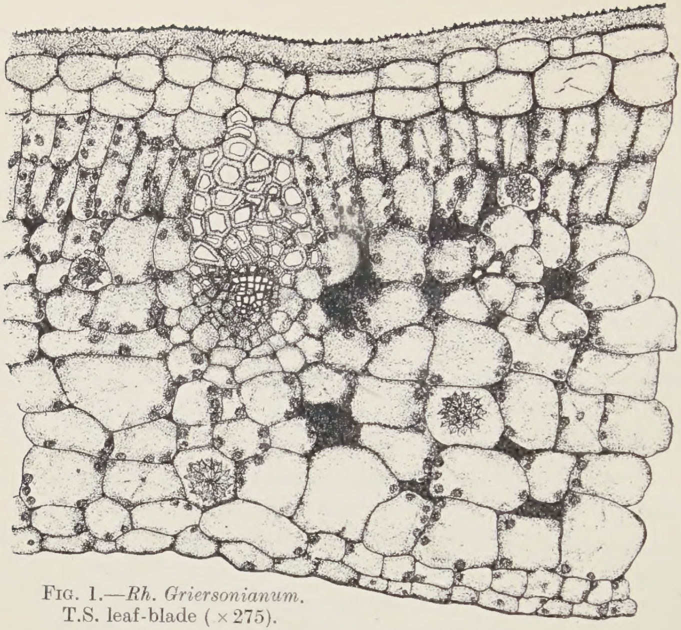

FIG. 1.—*Rh. Griersonianum.*
T.S. leaf-blade (× 275).

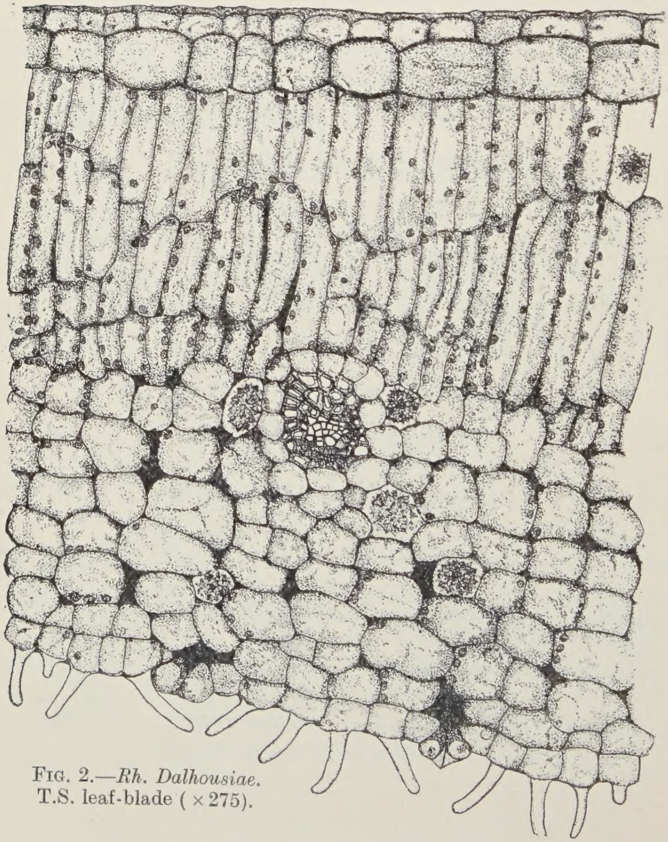

FIG. 2.—*Rh. Dalhousiae.*
T.S. leaf-blade (× 275).

TABLE V.—MORPHOLOGY OF THE FLOWER.

Character.	Rh. Griersonianum.	*Rh. Dalhousiae.*	Rh. Grierdal.
(i) *Calyx.*			
1. Colour	Red	*Green*	Red
2. Sepal:			
(*a*) Shape	Reniform	*Ovate-obtuse*	*Ovate-obtuse*
(*b*) Size	0·5 × 0·5 cm.	1·0 × 0·5 *cm.*	1·0 × 0·5 *cm.*
(*c*) Venation	Obscured by tomentum	*Not obscured*	*Not obscured*
(*d*) Indumentum	Dendriform hairs	*Scales + unicellular hairs*	*Scales + unicellular hairs*
(*e*) Margin	Dendriform hairs	*Glabrous*	*Scales* + hairs
(ii) *Corolla.*			
1. Colour	Scarlet	*White*	Scarlet
2. Stippling	Stippled	*Unstippled*	Stippled
3. Form	Tubaeform	*Campanulate*	Tubaeform
4. Base	Grooved	*Foveolate*	Grooved
5. Width at base	0·5 cm.	2·5 *cm.*	1 *cm., intermediate*
6. Overall length	5·5 cm.	9·5 *cm.*	9·0 *cm.*
7. Maximum width	7·0 cm.	9·5 *cm.*	8·0 *cm., intermediate*
8. Length undivided	3·0 cm.	7·5 *cm.*	7·0 *cm.*
9. Lobe:			
(*a*) Width at base	1·4 cm.	3·7 *cm.*	2·5 *cm., intermediate*
(*b*) Width	2·5 cm.	4·0 *cm.*	3·5 *cm., intermediate*
(*c*) Length	3·0 cm.	3·0 *cm.*	3·0 cm.
(*d*) Apex	Notched	*Not notched*	Notched
10. External surface	Hairy at base	*Scaly at base*	*Scaly at base*
11. Internal surface	Conoid hairs at base	*Base glabrous*	*Base glabrous*
(iii) *Androecium.*			
1. Length of stamens	4·5 cm. and 3·5 cm.	7·5 *cm. and* 7·0 *cm.*	6·6 cm. and 5·0 cm., *intermediate*
2. Colour of filament	Red	*Green*	Red
3. Base of filament	Bulbous	*Cuneate*	Bulbous
4. Density of pubescence	+ conoid hairs	+ + + *conoid hairs*	+ +, *intermediate*
5. Length of anther	0·3 cm. and 0·2 cm.	1 *cm. and* 0·8 *cm.*	0·6 cm. and 0·4 cm., *intermediate*
6. Colour of anther	Black	*Light brown*	*Dark brown, intermediate*
7. Base of lobe	Left lobe curved	*Lobes straight*	Left lobe curved
(iv) *Gynaeceum.*			
1. Length	Exceeds corolla	*Equal to corolla*	*Equal to corolla*
2. Ovary:			
(*a*) Length	0·5 cm.	1·0 *cm.*	1·0 *cm.*
(*b*) Indumentum	Densely hairy	*Densely scaly*	*Densely scaly*
(*c*) Basic colour	Red	*Green*	*Green*
(*d*) T.S.	Ridged	*Smooth*	*Smooth*
3. Style:			
(*a*) Base	Concealed by tomentum	*Not concealed*	*Not concealed*
(*b*) Indumentum	Hairs	*Scales*	*Scales*
(*c*) Colour	Red	*Green*	*Green*
4. Stigma:			
(*a*) Size	Small	*Large*	Small
(*b*) Colour	Maroon	*Yellow*	*Yellow*

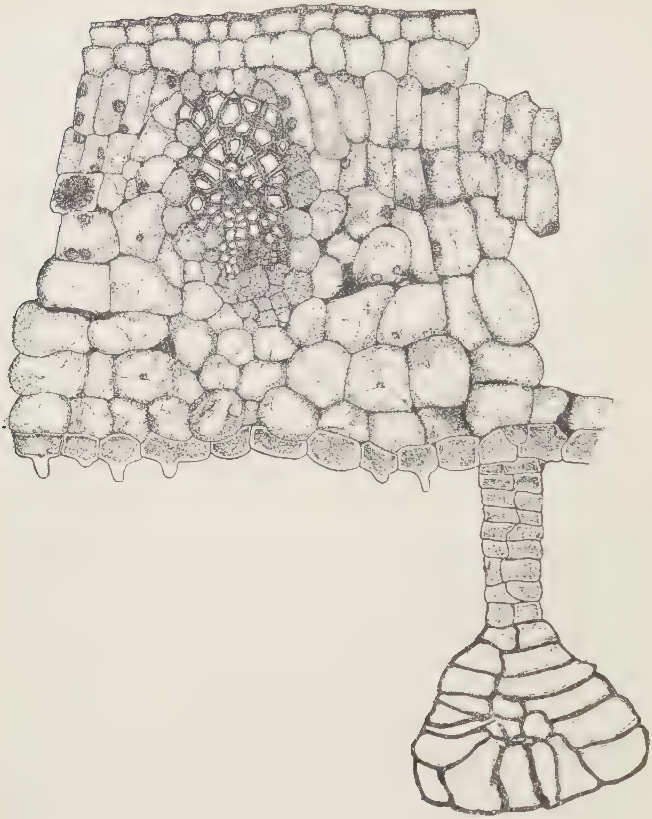

Fig. 3.—*Rh. Grierdal.* T.S. leaf-blade (× 275).

Development of Hairs and Scales.

Rh. Griersonianum.—On the upper and lower surfaces of the lamina there are dendriform hairs (fig. 4). The stalk of a hair measures 12·0–20 $\mu \times 8{\cdot}0$–$10{\cdot}0\ \mu$, and is composed of 6 tiers of thick-walled cells. Each tier consists of 1–2 central cells peripherally surrounded by a further 5–6 cells. The stalk is surmounted by a series of adpressed, cylindrical cells forming a column twice its length. The cells above this column are elongated to a further extent and ultimately separate. These cells intertwine and give the hair its typical dendriform appearance.

Each hair develops from a single cell which increases in size (fig. 5), and divides longitudinally to give the two-celled stage. The second division is again longitudinal, while the third is transverse. The hair now consists of 8 cells arranged in two tiers. Subsequent divisions occur in radial and transverse planes. In the last stage illustrated (fig. 5, F) the stalk has been completed by the thickening of the cell walls, and only the upper portion of the hair will continue to develop.

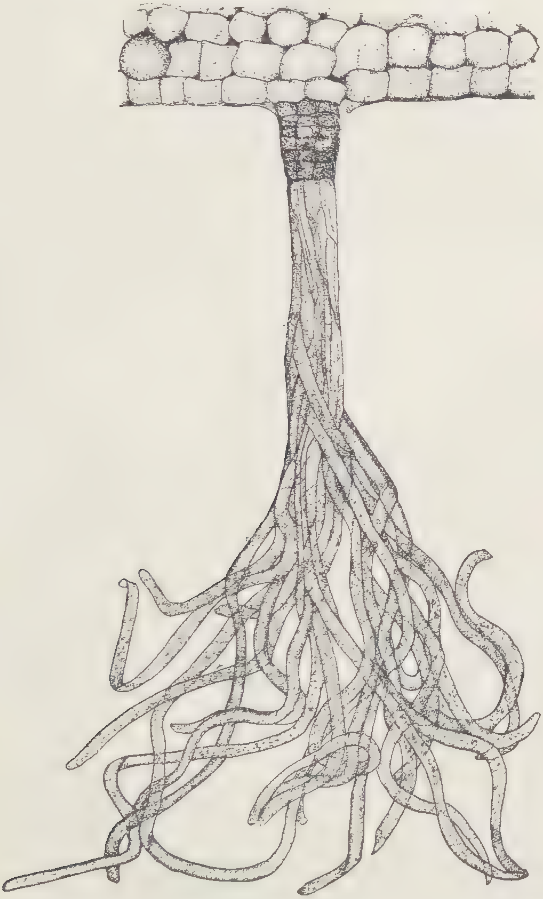

FIG. 4.—*Rh. Griersonianum.* Dendriform hair (× 275).

In the bud the foliage leaves are revolute, and in addition to dendriform hairs there are numerous unicellular conoid hairs. Each develops from an enlarged epidermal cell on the under surface of the leaf. The first and only division is transverse; the upper cell forms the conoid hair, which is pushed up by the lower cell to lie above the epidermis.

Rh. Dalhousiae.—Scales (fig. 6) occur on both sides of the lamina. The stalk consists of 5–6 tiers of 4 cells, each cell is thick-walled and has dark contents. The head can be divided into two parts—the basal portion and the upper expanded shield. The basal portion consists of 2–3 tiers of elongated flattened cells with heavily cutinised walls. The cells of the head proper are of two types—a central core of vertically elongated cells and a peripheral ring of radially expanded cells.

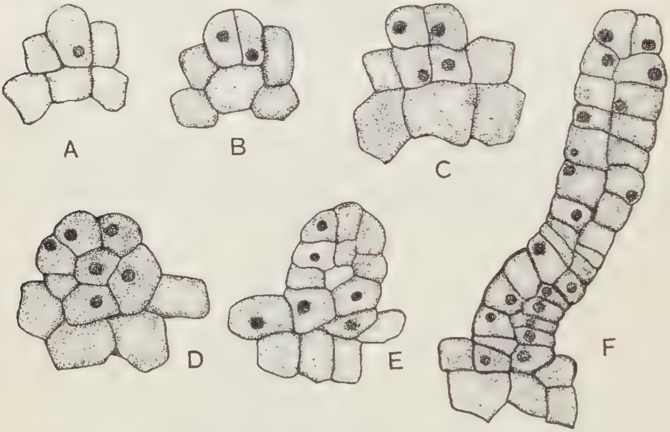

Fig. 5.—*Rh. Griersonianum.* Development of hair (× 275).

The first three stages in scale development are identical with those of the hair in *Rh. Griersonianum* (fig. 7, A, B, C). The basal four cells in stage C represent the stalk in embryo, while the upper cells give rise to the head. The base of the head is formed by the transverse division of the upper cells (fig. 7, D, E); the uppermost cells then divide radially—of these the central cells remain unmodified, and the outer cells expand peripherally (fig. 7, F). At a later stage in development (fig. 7, G) the stalk cells divide by transverse walls and form the adult stalk of 5–6 tiers.

In the bud the foliage leaves are involute and there are no conoid hairs.

Rh. Grierdal.—The hair (fig. 8) resembles a juvenile hair of

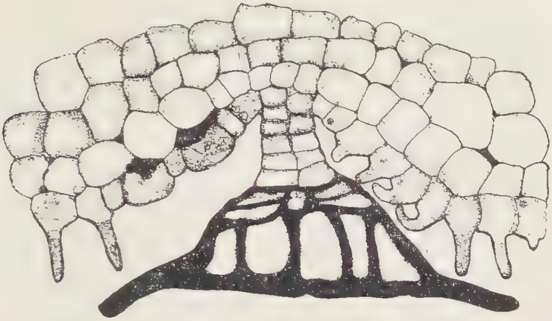

FIG. 6.—*Rh. Dalhousiae.* Peltate scale (× 275).

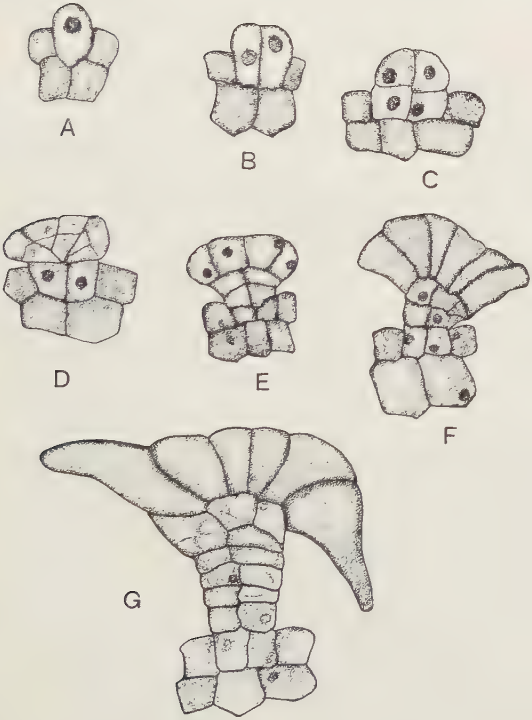

FIG. 7.—*Rh. Dalhousiae.* Development of scale (× 275).

Rh. Griersonianum—*i.e.* prior to the separation of the head cells. In development the two hairs are identical.

The scale is essentially similar to that of *Rh. Dalhousiae.*

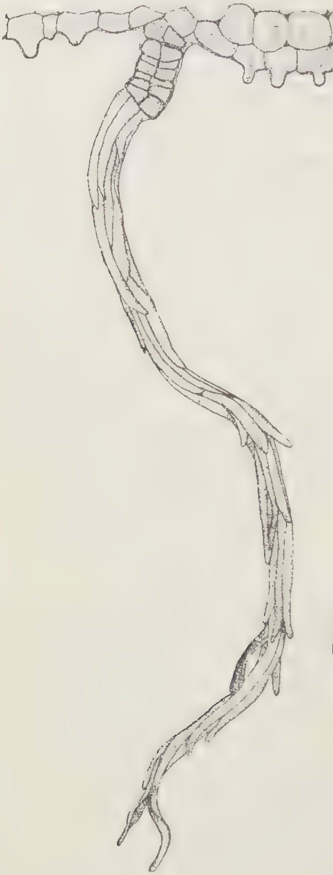

Fig. 8.—*Rh. Grierdal.* Hair (× 275).

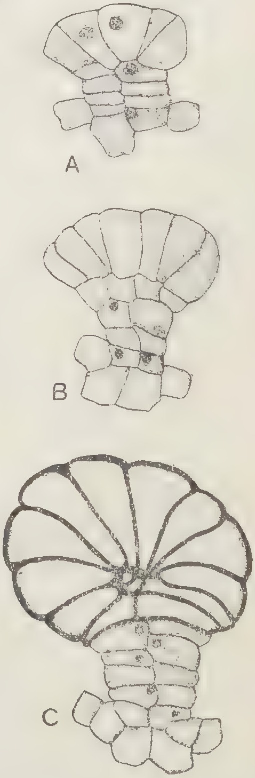

Fig. 9.—*Rh. Grierdal.* Development of scale (× 275).

The stalk consists of 9-14 tiers of cells, and the basal portion of the head is composed of 3–4 tiers of elongated, adpressed, thick-walled cells. Above these the cells are vertically elongated, but the peripheral cells are not radially expanded. The head therefore appears compactly rounded and there is no rim.

In development the hybrid scale agrees with that of *Rh. Dalhousiae* (fig. 9), and differs only in the later stages, where the peripheral cells of the head do not expand radially (fig. 9, C). The scale, in fact, may be described as a juvenile form of peltate scale which has acquired an abnormally long stalk.

It is remarkable that the scales and hairs of the hybrid are both juvenile forms.

In the bud the foliage leaves are involute as in *Rh. Dalhousiae*, and there are present the conoid unicellular hairs described in the bud leaves of *Rh. Griersonianum*.

Conclusion.

From a perusal of Tables I–V it may be seen that 39 per cent. of the hybrid characters are derived from *Rh. Griersonianum* (the female elepidote parent) and 49 per cent. from *Rh. Dalhousiae* (the male lepidote parent). The comparative anatomy of the three Rhododendrons thus gives confirmation that *Rh. Grierdal* is an authentic hybrid.

Acknowledgments.

I am greatly indebted to Professor Sir William Wright Smith for an abundant supply of material, and to Mr. John Anthony for much valuable assistance during the preparation of this paper. My thanks are also due to Miss Anna M. Macleod for permission to use her excellent Newskin Technique.

References.

Balfour, I. B.: New Species of Rhododendron. Notes Roy. Bot. Gard. Edin., xi (1919), 69–71.

Breitfeld, A.: Der anatomische Bau der Blätte der Rhododendreae in Berziehung zu irher Systematischen Verbreitung. Bot. Jahrb., ix (1888), 330.

Hooker, J. D.: Rh. Dalhousiae. Bot. Mag. J., 4718 (1857). Rh. Dalhousiae. The Rhododendrons of the Sikkim Himalaya, T. 1, 2 (1849).

Macfarlane, J. M.: A Comparison of the Minute Structure of Plant Hybrids with that of their Parents. Trans. Roy. Soc. Edin., xxxvii (1891), 252.

Meunnisser, A.: Rh. Griersonianum. Rev. Hort. (1928), 16.

Vesque, J.: Caractères de Gamopétales. Serié 2. Heteromères. Class iv, Ericales. Ann. Sc. Nat., sér. 7, i (1885), 238–240.

The Species of Rhododendron, published by the Rhododendron Society (1930), 49 and 492.

The Year Book of the Rhododendron Association (1938), 302.

THE SIGNIFICANCE OF THE DISTRIBUTION OF STOMATA ON THE LEAVES OF THE GENUS *Primula*. By ANNA M. MACLEOD, B.Sc.

(Read 15th June 1939.)

INTRODUCTION.

The genus *Primula* is divided into two groups, the Revolutae and the Involutae, based on the folding of the young leaf. In the Revolutae the leaf margins are curled downwards towards the middle of the lower epidermis; in the Involutae the leaf is folded in an upward direction. This difference in the folding of the young leaf has always been regarded as a reliable distinction between the two groups (3, 4, and 5).

Kamienski (1) recorded that, in *Primula*, the stomata may be present on both surfaces of the leaf blade, and noted that, in certain species, these stomata may be more numerous on the upper epidermis than on the lower. He found that the internal leaf structure was essentially the same in all the species he studied. Subsequent anatomical studies of the genus have, therefore, been concentrated on stem and root structure; while the distribution of stomata and the associated changes in the leaf have not been explained.

The species with the majority of their stomata on the upper epidermis, which Kamienski described, are all members of the section *Auricula* (Involutae).* For a considerable time this section and *Verticellata* alone comprised the Involutae, but recently, as a result of more accurate observation, it was discovered that all the members of *Cuneifolia* and a few species of the *Nivales*—which are now placed in the section *Parryi*—should also be included in the Involutae (4).

With this improvement in classification it became possible to make more general comparisons throughout the genus. The distribution of stomata on the leaves became of greater interest, and the question arose as to whether the predominance of stomata on the upper epidermis was a character exclusive to some *Auricula*, a general feature of the Involutae, or an unimportant detail common to many different species of both Revolutae and Involutae.

---

* The names of the sections and the specific names are as in (4) and (5).

The following investigation was therefore undertaken to obtain details of the distribution of stomata, to correlate this stomatal distribution with leaf anatomy and bud structure, and, if possible, to ascertain the factors governing the position of the stomata on the leaves of species of the genus *Primula*.

TECHNIQUE.

Species of *Primula* were chosen representative of as many different sections as possible, and healthy adult leaves from several different plants of each were preserved in Bles solution.

The stomatal distribution was ascertained from impressions of the leaf surface on a thin film of collodion (2). The collodion solution used was the trade preparation New Skin. It was found that maximum visibility was achieved when the resultant strips were mounted in air. Each strip was covered with a round ¾-in. cover-glass, and ringed with a solution of gum mastic in paraffin wax (6). The instrument used for ringing consisted of a short piece of ¾-in. brass tubing soldered to a rubber-covered brass handle. The brass tube was heated, then pressed firmly on the wax-mastic solution. The heat of the tube melted some of the solution, which adhered to the hot brass. The tube with the hot solution was applied to the junction of cover slip and slide, and, on touching the cold glass, the solution hardened immediately to form a clean ring. Other ringing solutions, such as black cement and gold size, tended to run under the cover slip and spoil the preparation.

The counting of stomata was carried out with the aid of a projection apparatus. An area of 2 sq. mm. of the epidermal impression was projected on to white squared paper; the number of stomata on large areas of the leaf could thus be rapidly and accurately ascertained.

Leaves of representative species were embedded from the material preserved in Bles solution. Buds were obtained in early spring, fixed in chromo-acetic acid, and embedded. All the leaf and bud sections were stained with gentian violet and Bismarck brown.

OBSERVATIONS.

1. EPIDERMAL PREPARATIONS.—When stomatal counts had been made for several different leaves of each species, it was

found that there was considerable variation in the absolute number of stomata on any definite area of the leaf surface. Slight differences in the humidity of the atmosphere, and other varying external factors, are known to affect the frequency of the stomata. The proportion, however, on the upper and lower epidermis remained relatively constant. The results throughout have, therefore, been expressed as percentages of the total number of stomata on both upper and lower epidermis.

The distribution of stomata varies considerably from species to species. The stomata may be:

(1) All on the lower epidermis.
(2) Most frequent on the lower epidermis.
(3) Most frequent on the upper epidermis.
(4) All on the upper epidermis.

Table I gives the stomatal distribution for each species.

TABLE I.—PERCENTAGE OF STOMATA ON THE LOWER EPIDERMIS OF SPECIES OF PRIMULA.

Group I. 100% below.	Group II. 99–55% below.	Group III. 54–1% below.
P. algida *	*P. anisodora* (74%)	*P. angustifolia* (39%)
P. amoena	*P. Boothii* (85%)	*P. argutidens* (50%)
P. atrodentata	*P. Bulleyana* (85%)	*P. Auricula* (12%)
P. aurantiaca	*P. burmanica* (98%)	*P. carniolica* (24%)
P. bellidifolia *	*P. Calderiana* (65%)	*P. hakusanensis* (52%)
P. darialica *	*P. capitellata* (90%)	*P.* × *kewensis* (52%)
P. denticulata *	*P. chionantha* (91%)	*P. marginata* (24%)
P. erythrocarpa	*P. Clarkei* (90%)	*P. nipponica* (51%)
P. Forrestii	*P. Dickieana* (63%)	*P. Palinuri* (34%)
P. Florindae	*P. Edgeworthii* (81%)	*P. Parryi* (40%)
P. geraniifolia	*P. effusa* (75%)	*P. suffrutescens* (33%)
P. imperialis	*P. frondosa* (85%)	
P. Inayatii	*P. helodoxa* (86%)	
P. megaseaefolia	*P. Juliae* (77%)	
P. Mooreana	*P. Kingii* (63%)	Group IV. 0% below.
P. nutans	*P. laciniata* (75%)	
P. pulverulenta	*P. Littoniana* (88%)	
P. rotundifolia	*P. luteola* (66%)	
P. sinolisteri	*P. petrocharis* (86%)	
P. sonchifolia	*P. Poissonii* (64%)	*P. Clusiana*
P. sphaerocephala	*P. pudibunda* (78%)	*P. glaucescens*
P. Stuartii	*P. rosea* (76%)	*P. hirsuta*
P. tosaensis	*P. sikkimensis* (91%)	*P. spectabilis*
P. werringtonensis	*P. sinopurpurea* (80%)	*P. viscosa*
	P. vittata (74%)	*P. Wulfeniana*

* An occasional leaf from these species had a few stomata on the upper epidermis also.

All the species of Group I—*i.e.* species whose stomata are restricted to the lower epidermis—are members of the Revolutae. They represent seventeen different sections. All the species of Group IV—*i.e.* species whose stomata are restricted to the upper epidermis—are members of the Involutae. They represent one section only, the section *Auricula*. The species of Group II are Revolutae; those of Group III, with one exception—*P. argutidens*—are Involutae. Thus there is clearly a tendency for the stomata of the Revolutae to be mainly on the lower epidermis, and for those of the Involutae to be mainly on the upper epidermis.

Certain species from Groups II and III belong to sections also represented in Groups I or IV. For example, *P. Poissonii* (64 per cent.), *P. anisodora* (74 per cent.), *P. Bulleyana* (85 per cent.), *P. helodoxa* (86 per cent.), and *P. burmanica* (98 per cent.) belong to the section *Candelabra*, three species of which, *P. aurantiaca*, *P. imperialis*, and *P. pulverulenta*, are in Group I. Similarly *P. Palinuri* (34 per cent.), *P. marginata* (24 per cent.), *P. carniolica* (24 per cent.), and *P. Auricula* (12 per cent.) belong to the section *Auricula*, other species of which are in Group IV. Similar series may be formed for other sections.

Nineteen out of twenty sections of the Revolutae have an average of over 75 per cent. of the stomata on the lower epidermis; all the four sections of the Involutae have an average of less than 55 per cent. of the stomata on the lower epidermis.

In the remaining section (*Amethystina*) the details of stomatal distribution do not fit into the general scheme.

Two species of *Amethystina* (*P. Kingii* and *P. Dickieana*), with 63 per cent. of their stomata on the lower epidermis, can be associated with outlying species of the *Candelabra*, *Farinosae*, and *Petiolares*. *P. argutidens*, however, with only 50 per cent. of the stomata on the lower epidermis, is widely separated from the other species of the Revolutae.

The species of *Primula* may now be placed in three distinct classes based on the stomatal distribution on the leaf:

(1) There are typical Revolutae in which more than 60 per cent. of the stomata are on the lower epidermis.

(2) There are typical Involutae in which less than 55 per cent. of the stomata are on the lower epidermis.

(3) There is one aberrant section. *Amethystina* (Revolutae) contains one species whose stomata are distributed in a manner typical of the Involutae.

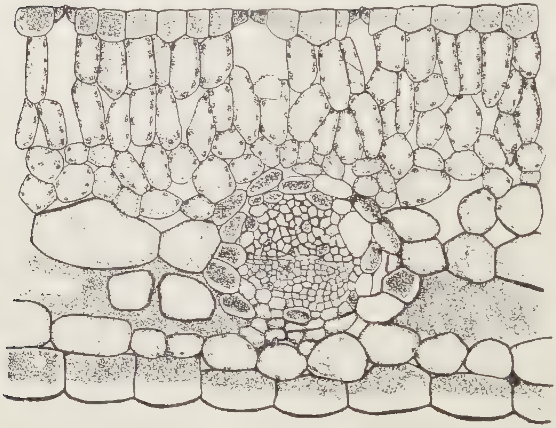

FIG. 1.—*P. glaucescens*. T.S. leaf. (×185.)

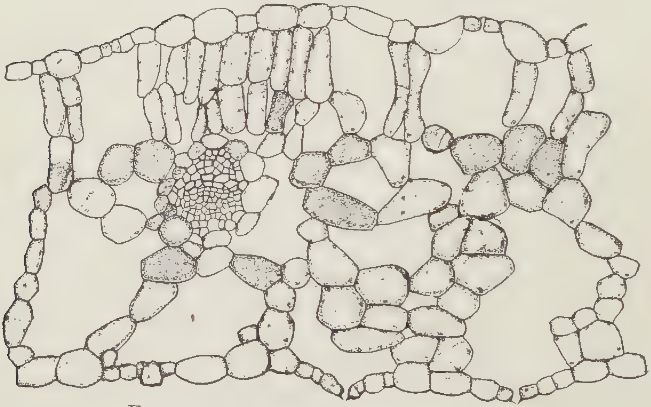

FIG. 2.—*P. Parryi*. T.S. leaf. (×185.)

2. LEAF STRUCTURE.—Species from different sections of the genus were examined to see if the internal structure of the leaf was in any way affected by the position of the stomata.

The distribution of air-spaces varies from species to species. Using this as a basis of classification, four main types of structure may be distinguished:

Type I. Air-spaces mainly in the palisade. See fig. 1.
Type II. Air-spaces general throughout the mesophyll. See fig. 2.
Type III. Air-spaces mainly in the lower mesophyll. See fig. 3.
Type IV. Air-spaces apparent only directly beneath the stoma pore. See fig. 4.

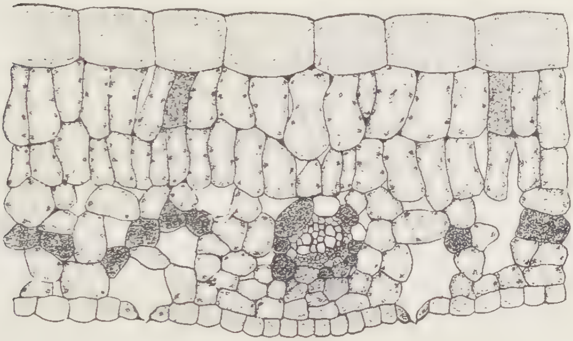

Fig. 3.—*P. Inayatii.* T.S. leaf. (×160.)

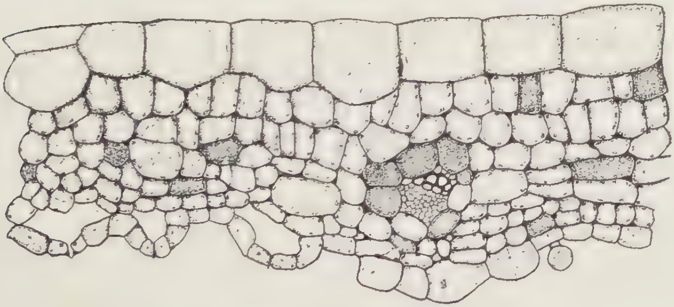

Fig. 4.—*P. erythrocarpa.* T.S. leaf. (×160.)

The leaves of species of the Involutae examined are of Type I (Section *Auricula* only) or Type II. The leaves of species of the Revolutae examined are of Type III or Type IV, with the exception of *P. Dickieana* and *P. argutidens* (*Amethystina*) which are of Type II. This section has already been noted as containing species with an unusual stomatal distribution.

3. Bud Structure.—It was noted that no stomata or air-spaces can be observed in the leaves of the dormant buds. Air-

spaces are apparently not formed till dormancy is broken and the leaves have started expanding. In the Revolutae the lower epidermis of the young leaf receives considerable protection from the inrolling of the leaf margins; in the Involutae, however, where conduplicate folding of the leaf is so common, it is difficult to maintain that one epidermis receives more protection than the other.

DISCUSSION.

The anatomical structure of the leaves and buds of *Primula* affords a possible explanation of the different stomatal distributions apparent throughout the genus.

The expansion of the young involute leaf puts a considerable strain on the upper layers of the mesophyll. The formation of a flat, uniform, adult blade from a young involute leaf would entail the formation of more cells in the upper tissues of the leaf. The adult blade, however, is rarely uniform—the cells vary in shape and size and air-spaces are present. In the Involutae these air-spaces are well marked in the palisade, where the tension on the developing leaf is greatest. Conversely, in the Revolutae, such air-spaces as are present are well marked in the lower mesophyll—again the tissue experiencing the greatest strain at leaf expansion. Stomata are associated with the air-spaces, being more numerous on the upper epidermis of Involutae and on the lower epidermis of Revolutae.

The part played by tensions on different parts of the mesophyll can afford only a partial explanation of the stomatal distribution in the adult leaf. It cannot account for the formation of stomata on the lower epidermis of Involutae or on the upper epidermis of Revolutae. It seems probable, however, that the presence of stomata on the upper epidermis of Involutae and on the lower epidermis of Revolutae is associated with the different tensions on the young leaf. The development of stomata on the lower epidermis of Involutae (ranging from 52 per cent. to 0 per cent.) and on the upper epidermis of Revolutae (ranging from 50 per cent. to 0 per cent.) is determined by some other factor or factors, as yet undetermined.

SUMMARY.

In the genus *Primula* the stomata on the leaf may be:

(*a*) all on the lower epidermis;
(*b*) all on the upper epidermis;
(*c*) on both lower and upper epidermis.

The species with stomata all below are Revolutae. Those with all above are Involutae. Those with stomata on both lower and upper epidermis include species from both Revolutae and Involutae.

All the species of the Revolutae except one (*P. argutidens*) have more than 60 per cent. of their stomata on the lower epidermis. All the species of the Involutae have less than 55 per cent. of their stomata on the lower epidermis.

In the leaf the air-spaces may be:

(*a*) mainly in the upper mesophyll;
(*b*) general throughout the mesophyll;
(*c*) mainly in the lower mesophyll;
(*d*) absent from the mesophyll.

The leaves of species of the Involutae are constructed on plan (*a*) or (*b*). The leaves of species of the Revolutae are constructed on plan (*c*) or (*d*), with the exception of *P. argutidens* and *P. Dickieana* which are of type (*b*).

Air-spaces are absent from the leaves of the dormant buds.

The theory is advanced that stomata are developed on that portion of the leaf which is under the greatest tension at expansion. This theory is seen to afford only a partial explanation of the stomatal distribution; the presence of stomata on the upper epidermis of Revolutae and on the lower epidermis of Involutae is dependent on some other factor.

ACKNOWLEDGMENTS.

I am greatly indebted to Professor Sir William Wright Smith for a most generous supply of material, and to Mr. John Anthony for much assistance in the preparation of the paper.

REFERENCES.

(1) KAMIENSKI, F. VON: Zur Vergleichenden Anatomie der Primeln. Strassburg, 1875.

(2) LONG, F. L., and CLEMENTS, F. E.: The Methods of Collodion Films for Stomata. Amer. Jour. Bot., xxi (1934), pp. 7–17.

(3) PAX, F., and KNUTH, R.: Das Pflanzenreich—Primulaceae. 1905.

(4) SMITH, W. W.: The Hooker Lecture (1933): Some Aspects of the Bearing of Cytology on Taxonomy. Proc. Linn. Soc. Lond., Sess. 145 (1932–33), pp. 151–181.

(5) SMITH, W. W., and FORREST, G.: The Sections of the Genus Primula. Journ. Roy. Hort. Soc., liv (1929), pp. 1–50.

(6) THOMAS, H. H.: On a New Method of Sealing up the Cover Glasses of Preparations mounted in Glycerine. New Phyt., x (1911), pp. 105–106.

SEASONAL CHANGES IN TIDAL POOLS.

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(Read 29th February 1940.)

On the rocky shore in the vicinity of St. Andrews, on the east coast of Fife, there is a large number of tidal pools with a varying vegetation. This flora was examined during the spring and early summer of 1938 while a survey of the marine algae in the district was being carried on. It was thought then that the times at which the annuals appeared in the pools were abnormal, and therefore the same pools were closely watched during the same months of 1939 in order to compare the growth throughout the two seasons. From a comparison of the records for the two seasons, which differed very much in climatic conditions, it is shown that the growth of the algae in the pools is influenced by the weather conditions.

The vegetation of the pools varies with the conditions of exposure, the position in the littoral region, the depth and the substratum, as well as with the season of the year. Some of the plants found in the pools are amongst those which compose the associations on the surrounding rocks, while others cannot withstand exposure to the air and are confined to the pools, e.g. *Halidrys siliquosa.* The bathymetric range of many species is extended because of the pools. *Dumontia incrassata* and *Cystoclonium purpureum*, for instance, are commonly found on rocks exposed by the tide at low water, but they also grow in pools up near high water. Similarly, *Phycodrys rubens*, which is at its best development as a sub-littoral species, may be collected from pools far up the shore.

TYPES OF POOLS.

(*a*) Many of the pools in the lower part of the littoral region are just parts of the sub-littoral region isolated by the retreat of the tide and contain a similar flora. These may be on the rocky ledges where small red algae, especially Polysiphonias, are frequent, or with a sand or gravel substratum, when *Polyides* and *Ahnfeltia* are co-dominant. Increase of sand lessens the variety of species, and *Polysiphonia nigra* may be the only inhabitant of the sandiest pools in the winter, accompanied by *Ceramium rubrum* in summer.

(*b*) Many pools are hollows in the rock surface. The smallest of these are often monopolized by *Cladophora rupestris* and many are lined by an encrustation of *Lithothamnion polymorphum* along with the tufted *Corallina officinalis*. Deeper hollows may have the *Lithothamnion* and *Corallina* on the sloping sides, with Laminarias below and a band of *Cladophora rupestris* round the top. If a little sand is deposited in these hollowed pools, the encrusting form is absent, and *Corallina* is accompanied by a more varied flora, including *Polysiphonia nigrescens* and *Dumontia incrassata*, with *Ulva latissima* often dominant during summer.

(*c*) In the mid-littoral region there are many large, deep pools lying between the ridges of rock, with a sandy or pebbly bottom, and embedded stones and boulders. These are often well-sheltered, and contain *Halidrys siliquosa* as the dominant plant, varying in size and luxuriance with the depth of the pool, and accompanied by Laminarias, Fuci, *Polysiphonia elongata*, etc.

(*d*) On the upper half of the littoral region the pools have a varied flora. Those about one foot deep have often *Polysiphonia nigrescens* and *Rhodomela subfusca* as co-dominants, while others, shallower and with pebbles as substratum, have *Dumontia incrassata* and *Laurencia caespitosa* as their principal inhabitants. In a few pools in the *Fucus spiralis* zone, *Sphacelaria racemosa* has been found. This is a rare plant and has not been recorded since 1887, when Batters records it for Berwick [see Holmes (1887)]. Racemes of ripe sporangia were found in February. It is these pools that change most in spring and early summer and they will be referred to below.

(*e*) In the pools at high water the Chlorophyceae are dominant—*Cladophora rupestris*, *Monostroma Grevillei*, and *Enteromorpha* spp. being the most noticeable.

(*f*) Above high water, at a few places where the rock is flat and not covered by sand or shingle, there are shallow pools which are only reached by a very high tide and are filled up by rain, so that the water is brackish. *Enteromorpha intestinalis* is the sole occupant of these pools.

The pools in the upper half of the littoral region change most in appearance during the seasons. The species mentioned above are the winter dominants. These are mostly Rhodophyceae, which become fertile in the early months of the year, producing tetraspores and cystocarps from January to March or April. During the months of spring and early summer the summer annuals, mostly green algae and brown algae, gradually appear (Table IV) and spread down the shore. The vegetation of the pools at this time becomes very dense. Some of these annuals, e.g. *Phyllitis* and *Monostroma*, have a short season, dying out in June, while others last on into the autumn.

This change in the character of the pools is also closely connected with epiphytism, a layer of annuals often being superimposed on the perennial plants which were at the height of their growth and development during the winter and early spring. Epiphytism becomes very noticeable in May, and the Rhodophyceae may be quite overgrown by green and brown species (Table II). A number of epiphytes are often found on the same plant, and they, in turn, may have smaller epiphytes on them. As an example, the following list is given of the epiphytes growing on a plant of *Polysiphonia nigrescens* during May:—

Monostroma Grevillei Wittr.
Ectocarpus parasiticus Sauv.
Ectocarpus confervoides Je Jol.
Pylaiella littoralis Kjellm.
Asperococcus fistulosus Hook.
    with Myriotrichia filiformis Harv.
Sphacelaria cirrhosa C. A. Ag.
Ceramium rubrum C. A. Ag.
Schizomena sp.
    with Chlorochytrium Cohnii Wright.

On the more exposed shore there are fewer pools with a dense flora. On the lower part of the littoral region there are some of the Coralline type, but above that the pools may be devoid of any vegetation. If the surrounding rocks afford shelter from buffeting, vegetation appears similar to that of the more sheltered shore.

Below is given, in Table I, a list of the species collected in the pools, with the zone of occurrence and the frequency during the seasons. In Table II (p. 26), a list of the epiphytic forms with their hosts and frequency is given. Amongst these forms an interesting find was a single specimen of *Colpomenia sinuosa* growing on *Halidrys* in a mid-tide pool in a comparatively sheltered position. This is a Mediterranean species which was first found in the south of England in 1908 and has since been spreading northwards. Lynn (1935) found it at several places in N. Ireland in 1934. In the east, Chapman (1937) records it for the Norfolk coast, but this is the first time it has been recorded for Scotland.

TABLE I.

LIST OF SPECIES FOUND IN POOLS.

a: abundant.
o: occasional.
s: sporadic appearance.
f: frequent.
y: young plants.

Species.	Zone of Occurrence.			Seasonal Frequency.			
	h.w.	mid.	l.w.	Spr.	Sum.	Aut.	Win.
Enteromorpha compressa Grev. .	×	×	×	f	a	f	o
,, *intestinalis* Link .	×	. .	. .	a	a	o	o
Monostroma Grevillei Wittr. . .	×	×	×	f	f	. .	o
,, *fuscum* Wittr. . .	. .	×	×	o	o	. .	. .
Ulva lactuca Linn. var. *latissima* DC.	. .	×	×	f	a	fy	f
Cladophora rupestris Kütz. . .	×	×	×	a	a	a	f
,, *sericea* Kütz. . .	×	. .	. .	o	o	. .	. .
,, *flexuosa* Harv. . .	. .	×	×	o	o	. .	. .
,, *refracta* Aresch. . .	. .	×	. .	. .	o	. .	. .
,, *albida* Kütz. . .	. .	. .	×	. .	o	. .	. .
Chaetomorpha melangonium Kütz. .	. .	×	. .	f	f	f	o
Bryopsis plumosa C. A. Agardh .	. .	×	×	o	. .	o	o
Ectocarpus confervoides Le Jol. .	×	×	×	o	f	o	. .
,, *granulosus* C. A. Agardh	. .	×	. .	o	o	o	. .
Chordaria flagelliformis C. A. Agardh	. .	×	×	o	a	f	. .
Castagnea virescens Thur. . .	. .	×	. .	o	f	. .	. .
Ralfsia verrucosa Aresch. . .	×	×	. .	f	f	f	f
Dictyosiphon foeniculaceus Grev. .	. .	×	. .	. .	f	o	. .
Asperococcus fistulosus Hook. .	. .	×	. .	. .	f	f	. .
,, ,, ,, var. *vermicularis* Griff.	×	. .	. .	f	. .	f	f
Phyllitis Fascia Kütz. . . .	×	×	. .	f	. .	s	. .
Scytosiphon lomentarius J. G. Agardh	×	×	. .	o	o	o	. .
Stictyosiphon subarticulatus Hauck	. .	×	. .	f	o	oy	f
Punctaria plantaginea Grev. . .	×	×	×	f	f	o	oy
Sphacelaria racemosa Grev. . .	×	. .	. .	. .	. .	. .	o
,, *plumigera* Holm. .	. .	×	. .	. .	. .	. .	o

TABLE I—*continued.*

Species.	Zone of Occurrence.			Seasonal Frequency.			
	h.w.	mid.	l.w.	Spr.	Sum.	Aut.	Win.
Laminaria hieroglyphica J. G. Agardh	..	×	×	f	f	f	f
Laminaria digitata Lamour	..	×	×	f	f	f	f
Alaria esculenta Grev.	..	..	×	o	o	o	o
Dictyota dichotoma Lamour	..	..	×	..	o	..	..
Fucus ceranoides Linn.	×	..	..	o	o	o	o
,, *vesiculosus* Linn.	..	×	..	f	f	f	f
,, *serratus* Linn.	..	..	×	f	f	f	f
Himanthalia lorea Lyngb.	..	..	×	o	o	o	o
Halidrys siliquosa Lyngb.	..	×	×	a	a	a	a
Gelidium corneum Lamour	..	×	×	f	f	f	f
Dumontia incrassata Lamour	×	×	×	a	f	fy	a
Polyides rotundus Grev.	..	×	×	f	f	f	f
Lithothamnion Lenormandi Foslie	..	×	..	f	f	f	f
,, *polymorphum* Foslie	..	×	×	f	f	f	f
Corallina officinalis Linn.	..	×	×	a	a	a	a
Phycodrys rubens Batt.	..	×	×	o	o	o	o
Rhodomela subfusca C. A. Agardh	..	×	..	a	f	fy	a
Laurencia caespitosa Lamour	×	×	×	f	f	fy	f
Polysiphonia urceolata Grev.	..	..	×	f	f	..	f
,, *nigra* Batt.	..	×	×	a	a	f	fy
,, *elongata* Harv.	..	×	×	f	o	f	f
,, *fibrata* Harv.	..	×	..	o	..	..	..
,, *fibrillosa* Grev.	..	..	×	o	o	..	..
,, *violacea* Harv.	×	×	..	f	f	fy	f
,, *Brodiaei* Grev.	..	..	×	o	..	o	o
,, *nigrescens* Grev.	..	×	×	a	a	ay	a
Ceramium rubrum C. A. Agardh	..	×	×	f	a	o	o
Chondrus crispus Lyngb.	..	×	×	f	f	f	f
Gigartina stellata Batt.	..	×	×	f	f	f	f
Phyllophora Brodiaei C. A. Agardh	..	..	×	o	o	..	..
Ahnfeltia plicata Fries	..	×	×	o	o	o	o
Cystoclonium purpureum Batt.	..	×	×	f	a	..	oy
Lomentaria clavellosa Gaill.	..	..	×	..	o	..	..

Records were kept during the spring of two seasons, 1938 and 1939, of the first appearance of the annual plants. These seasons were very different, the first being very mild, March being exceptionally sunny and warm; the second more severe, January having a temperature below the average.

Table III (p. 27) shows these variations, compiled from the Monthly Weather Reports of the Meteorological Office (1938–39). As will be seen, the difference is marked in January, March, and April, and in these three months of 1938

TABLE II.

LIST OF EPIPHYTIC SPECIES FOUND IN POOLS.

Species.	Host.	Seasonal Frequency.			
		Spr.	Sum.	Aut.	Win.
Chlorochytrium Cohnii Wright	*Schizonema* sp.	..	f	..	..
Monostroma Grevillei Wittr.	Various.	f	f	..	o
Cladophora hirta Kütz.	*Polysiphonia nigrescens.*	f	..	o	o
,, *lanosa* Kütz.	Various.	f	f	..	..
Ectocarpus parasiticus Sauv.	Various.	..	f	f	..
,, *fasciculatus* Harv.	*Laminaria digitata.*	o	f	o	..
Elachistea flaccida Aresch.	*Halidrys siliquosa.*	..	o	..	..
,, *fucicola* Fries	*Fucus* spp.	o	f	f	o
Leathesia difformis Aresch.	Various.	f	a	o	..
Myrionema strangulans Grev.	*Entermorpha* spp.	..	o	..	..
Myrionema strangulans Grev. var. *punctiforme* Holm. et Batt.	*Cladophora rupestris.*	..	f	..	..
Ulonema rhizophorum Foslie	*Dumontia incrassata.*	o	..	..	..
Dictyosiphon hippuroides Kütz.	Various.	f	a	o	..
Colpomenia sinuosa Derb. et Sol.	*Halidrys siliquosa.*	o	..	..	..
Asperococcus fistulosus Hook.	Various.	o	f	o	..
Myriotrichia clavaeformis Harv.	Various.	..	o	..	..
,, *filiformis* Harv.	Various.	o	f	..	..
Punctaria tennuissimum Grev.	Various.	..	o	..	..
Sphacelaria cirrhosa C. A. Agardh var. *pennata* Hauck	Various.	a	o	f	a
Sphacelaria cirrhosa C. A. Agardh var. *fusca* Holm. et Batt.	Various.	..	o	o	..
Sphacelaria cirrhosa C. A. Agardh var. *aegagropila* Griff.	*Halidrys siliquosa.*	..	f	o	o
Sphacelaria caespitula Lyngb.	*Laminaria Cloustoni.*	..	..	..	o
Erythrotrichia carnea J. G. Agardh	Various.	..	f	f	..
Acrochaetium virgatulum J. G. Agardh	Various.	..	f	..	..
Acrochætium Daviesii Naeg.	Various.	o	f	..	..
Gelidium corneum Lamour	Various.	o	o	o	o
Ceramium diaphanum Roth.	Various.	..	o	..	..
,, *rubrum* C. A. Agardh	Various.	f	a	o	o
,, *fruticulosum* Kütz.	*Halidrys siliquosa.*	f	f	..	fy
ENTANGLED SPECIES:					
Ulothrix speciosa Kütz.	Various.	o	o	..	..
Chaetomorpha tortuosa Kütz.	Various.	o	f	o	..

there was exceptionally early growth of several species. The last column shows the sea temperature taken in the North Sea. The sea cooled down quicker in the autumn of 1937, so that it reached a lower temperature in February of 1938 than it did in 1939, although the air temperatures were higher.

TABLE III.

Date.	Remarks from Reports.	Mean Air Temp. ° F.	Variation from Average.	Sunshine. Daily Mean in Hrs.	Sea Temp. ° F.
1938					
Jan.	Mild; sunshine over average for E. Scot.	40	+2·0	2·37	44
Feb.	Mild.	41	+2·0	2·34	41
Mar.	Unprecedented mildness.	48	+7·8	4·15	43
Apr.	Excessive sunshine.	46	+2·1	4·92	44
1939					
Jan.	Cold.	37	−1·8	1·37	43
Feb.	Mild.	42	+3·7	2·44	43
Mar.	Average.	42	+1·4	3·63	43
Apr.	Sunny.	44	+0·3	5·45	43

TABLE IV.

Species.	Date of First Appearance.		Difference in Weeks.
	1938.	1939.	
Punctaria plantaginea Grev.	Jan. 6	Mar. 14	9
Monostroma Grevillei Wittr.	,, 15	Feb. 9	3½
Polysiphonia urceolata Grev.	,, 17	,, 7	3
Cystoclonium purpureum Batt.	,, 17	,, 10	3
Phyllitis Fascia Kütz.	Mar. 4	Mar. 13	1
Ectocarpus confervoides Le Jol.	,, 21	Apr. 11	3
Asperococcus fistulosus Hook.	Apr. 4	May 17	6
Ectocarpus tomentosus Lyngb.	,, 5	,, 22	6½
Chordaria flagelliformis C. A. Agardh	,, 25	June 7	6
Castagnea virescens Thur.	,, 26	,, 7	6
Dictyosiphon hippuroides Kütz.	,, 26	May 18	3
Leathesia difformis Aresch.	,, 28	,, 17	2½
Elachistea fucicola Fries	,, 28	,, 3	1
Isthmoplea sphaerophora Kjellm.	,, 29	,, 17	2½
Ectocarpus fasciculatus Harv.	May 2	,, 4	..
Myriotrichia filiformis Harv.	,, 3	,, 17	2
Cladophora lanosa Kütz.	,, 4	,, 24	3
Desmarestia viridis Lamour	,, 30	June 6	1

This high air temperature heated up the shallow pools in the *Fucus spiralis* zone, and here much of the early growth occurred, and is thus dependent on the air temperature rather than on the sea temperature. The position was higher on the shore than usual for species such as *Chordaria* and *Castagnea* which in the average season first appeared in pools in the *F. vesiculosus* zone.

Lastly, Table IV (p. 27) gives a list of those annuals with the times of appearance, and shows that this was consistently early in 1938.

SUMMARY.

Types of pools with varying vegetation are described.

Seasonal changes in these pools are noted, through the growth of annuals and epiphytism.

A list of species found in the pools is given, with the zone of occurrence and seasonal frequency.

A list of epiphytes is given with their host and frequency.

A new record for Scotland is noted—*Colpomenia sinuosa* found in May 1939.

It is shown that the extra sunshine and high air temperature during the early months of 1938 caused the annuals to appear much earlier than in an average season.

In conclusion the writer wishes to thank the Botanical Department of St. Andrews University for facilities to carry on the work. This was done during the tenure of a Carnegie Scholarship.

REFERENCES.

CHAPMAN, V. J., 1937: A Revision of the Marine Algae of Norfolk. Jour. Linn. Soc., Bot., li, p. 205.

HOLMES, E. M., 1887: Remarks on *Sphacelaria radicans*, Harv. and *S. olivacea*, J. Ag. Trans. Bot. Soc. Edin., xvii, p. 79.

LYNN, M. J., 1935: Rare Algae from Strangford Lough, Pt. II. Irish Nat. Jour., v, p. 275.

1937–1939: Monthly Weather Reports of the Meteorological Office.

EQUISETUM TRACHYODON AS A SCOTTISH PLANT.

By J. R. MATTHEWS, M.A.

(Read 21st March 1940.)

In view of the uncertainty which seems to have arisen regarding the occurrence of *Equisetum trachyodon* * in the north-east of Scotland and since the species is not known to occur elsewhere in Britain it may be of interest to review the main facts of its history as a British plant. The question was brought to my notice some time ago by Dr. Lloyd Praeger, who enquired whether I could give him any recent information about the occurrence of the plant on the banks of the River Dee, where it was discovered, along with *E. hyemale* and *E. variegatum*, by the Rev. J. B. Brichan in 1841. Whatever doubts may have arisen in the minds of later botanists, there is no ambiguity in the account of these three species which Brichan gives in "The Phytologist," i, pp. 369-377 (1842), "as found on the banks and in the bed of the River Dee." Not only does he give good descriptions of the plants as he observed them, but he reaches the conclusion that they are "well entitled to be ranked as distinct species." Regarding localities he states: "The three plants are found at various parts along the course of the Dee, within the parish of Banchory, extending over a space of six or seven miles in length. There are three distinct stations for *E. hyemale*, four for *E. Mackaii*, three for *E. variegatum*, and several intermediate spots in which detached plants of each species or variety, especially of *E. Mackaii*, occur."

In "Cybele Britannica," iii, p. 308 (1852), H. C. Watson admits *E. Mackaii* Newm. as British, and cites Babington's "Manual" for its occurrence in Ireland, Scotland, and England. Although not aware of any English localities, Watson refers to the Deeside stations and gives the foregoing extract from Brichan's paper. The species is retained in vol. iv of the "Cybele" (1859) and also in the "Supplement" (1860). But in the "Compendium," p. 605 (1870), although the Den of Airly is mentioned as an additional locality, Watson places *E. Mackaii* among the species excluded from the British flora on the grounds of ambiguity, "no specimens of this plant having come under my own inspection," and he goes on to say that he had not felt satisfied "about the reality of the species." It is true that Newman in "The Phytologist," i, p. 305 (1842), figured the plant as *E. hyemale* var. *Mackaii*, the varietal name being in honour of Dr. Mackay, whom Newman believed to have been the original discoverer of the plant in Colin Glen, near Belfast. It had, in fact, been previously found there by F. Whitla before 1830. In "History of British Ferns" (1844), however, Newman writes of the plant as *E. Mackaii*, but expresses some doubt as to its status. He acknowledges specimens received from Brichan for comparison with Irish material and has no hesitation in pronouncing the Scottish and Irish specimens identical. He quotes Brichan's published account of the Scottish plant together with his (Brichan's) opinion that *E. Mackaii* should be given specific rank. This was the view also of W. J. Hooker, who regarded the plant as identical with *E. elongatum* Willd. and under this name he included it in "British Flora," p. 451 (1842). Hooker and Arnott, however, in "British Flora" (1850) adopt Newman's name *E. Mackaii* and mention as localities: "Mountain Glens near Belfast: F. Whitla, Esqr., and Dr. Mackay; since found in the north of Ireland and in the bed of the River Dee in Scotland."

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* *Equisetum trachyodon* Braun = *E. Mackaii* Newman.

As we have seen, Watson (*op. cit.*, 1870) finally rejected the plant from his Synopsis of British Species, nor did it find a place in "Topographical Botany" (1883) or in either of the Supplements (1905, 1925) to that work. Turning to Syme's "English Botany," Ed. III, 12 (1886), we find the species recorded from Scotland and Ireland. Brichan's Kincardineshire localities are mentioned, but some doubt is expressed regarding them since "Aberdeen botanists do not seem to have observed this plant, as in answer to inquiries Dr. G. Dickie replied in Nov. 1874, 'I know nothing of *E. trachyodon* in this quarter; Mr. Roy says the same.'" Dickie probably never gathered the plant, but he includes it in his "Botanist's Guide to the Counties of Aberdeen, Banff, and Kincardine" (1860), describes it as very rare, and quotes Brichan's localities in the parish of Banchory. The statement in Syme's "English Botany" is, however, somewhat puzzling since there are three small sheets in Aber. Univ. Herb. labelled *E. hyemale*, *E. variegatum*, and *E. Mackaii* all from the "banks of the River Dee at Banchory" and dated 11th Aug., 13th Aug., and 16th Aug. 1842 respectively. The three labels are in the same handwriting; unfortunately they bear no collector's name. But since 1842 was the year of Brichan's published account of these three plants from the parish of Banchory it seems not improbable the gatherings were made by him at the time he was studying their characters and local distribution.* Another sheet in Aber. Univ. Herb. represents a gathering, also from Banchory, by J. Sim, June 1877, but the specimens are not quite characteristic. Through the kindness of the Director, Royal Botanic Gardens, Kew, I have been able to examine other two Scottish gatherings preserved in Herb. Kew. These are labelled (1) *Equisetum Mackaii* Newman, Banks of the Dee, Aberdeenshire, 1850, Wm. Borrer Esqr.,† and (2) *Equisetum trachyodon* A. Br., Deeside between Banchory and Aboyne, July 1871, Col. & Com. George E. Hunt. In Herb. Backhouse, preserved at the Royal Botanic Garden, Edinburgh, a sheet of *E. trachyodon* is labelled *Equisetum hyemale* var. *Mackaii*, Banks of the Dee, Kincardineshire, Col. J. B. Brichan, Comm. E. Newman (no date given). I am indebted also to the authorities of the Botany Department, Natural History Museum, South Kensington, for the information that in Herb. Brit. Mus. there is another undated specimen from the banks of the Dee near Banchory collected by the Rev. J. B. Brichan.

There seems little reason, therefore, why British botanists should ever have doubted the occurrence of this plant in Scotland, which had been clearly and unmistakably reported by Brichan nearly a century ago and supported by specimens in several herbaria. It is significant that Babington omitted reference to it as a Scottish plant in "Man. Brit. Bot.," Ed. 7 (1874), *i.e.* four years after the publication of Watson's "Compendium to Cybele Britannica"—an omission which has been continued in subsequent editions, yet in Ed. 5 (1862) and Ed. 6 (1867) the plant is reported from Scotland.

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* Brichan's paper is dated 4th October 1842.

† This gathering is a mixed one; of the three specimens on the sheet, the left-hand one is *E. variegatum*, the other two are *trachyodon*.

In the three editions of Hooker's "Stud. Fl. Brit. Isles" the plant is included under *E. variegatum* as var. *trachyodon* and recorded from N.E. Ireland and Scotland. Recent editions of the "London Catalogue of British Plants" give one British vice-county without question, but Druce in his "List of British Plants" (1928) queries the record from Kincardineshire, and in "Com. Fl. Brit. Isles" the same author states that this record needs confirmation.

The plant still grows on the banks of the Dee. In Sept. 1935 I found a good colony of it near the Bridge of Potarch, and as the locality is in Aberdeenshire the plant can be definitely recorded from v.-c. 92 S. Aber. I have not detected it within the parish of Banchory, but the Kincardineshire (v.-c. 91) record should stand in view of Brichan's original gatherings. It is not certain that either Borrer's or Hunt's specimens were collected within the Kincardineshire boundary.

The Scottish plant is very similar to specimens I have seen from Sweden and Central Europe. According to Schaffner in "Amer. Fern Journ.," 22, p. 125 (1932), the species is widely distributed in the northern part of the north temperate zone; in Ireland, Praeger ("The Botanist in Ireland") records it from sixteen vice-counties.

In recent years *E. trachyodon* has been regarded as a hybrid between *hyemale* and *variegatum*, but Schaffner in "Amer. Fern. Journ.," 21, p. 98 (1931) gives reasons for doubting this view. The plant is intermediate in size between these two species and can readily be distinguished by the tight cylindrical sheaths, becoming wholly black, bearing long more or less persistent teeth.

PRIMULA AURICULA IN ANGUS. By J. R. MATTHEWS, M.A.

(Read 21st March 1940.)

The occasion of this note is the finding in June 1939 of *Primula auricula* by one of my former students, Mr. J. Grant Roger, on a steep cliff at about 2700 feet on the eastern slopes of Glas Maol overlooking Caenlochan. The species was first observed in this locality by members of the Scottish Alpine Botanical Club in 1880. On the same excursion *Erinus alpinus* and *Myosotis alpestris* were also noted, and the three species were described as "all evidently introduced." Caenlochan has long been known for its rich alpine flora, and although I find no special mention of the area in the writings of George Don, he relates how "he has repeatedly ranged over the great mountains of Angusshire which surround the great district of Clova, where no one on a similar pursuit has ever preceded him." It is unlikely that Don, who discovered *Myosotis alpestris* on Ben Lawers, would have overlooked either this species or a plant so conspicuous as *Primula auricula* had they occurred on any of the Clova hills during his lifetime (1764–1814). From the records of J. H. Balfour's botanical excursions published in "Notes Roy. Bot. Gdn. Edin." (1902) it appears that Caenlochan was visited on six different occasions between the years 1847 and 1866, but there is no record of any alien species among the plants collected.

It is not until 1881 that we find any reference to the occurrence of *Primula auricula* in Angus. In that year, as reported in "Proc. Bot. Soc. Edin.," p. lxviii (1881), Mr. William Boyd communicated an account of the meeting of the Scottish Alpine Botanical Club at the Spittal of Glenshee on 29th July 1880. He describes how, on the following day, the party descended into the "Corry of Canlochan," having made the approach across the moors from the Cairnwell. After gathering *Sonchus alpinus* on the right-hand rocks, "well out of reach of ordinary collectors," and a number of other plants such as *Saussurea alpina*, *Dryas octopetala*, *Pyrola rotundifolia* and *Gentiana nivalis*, the party was "not a little astonished to observe the Swiss *Erinus alpinus*, *Primula auricula*, and *Myosotis alpestris* on the boggy soil covering some of the rocks, all evidently introduced." "Any botanist," the account goes on, "capable of perpetrating a hoax of this kind is unworthy of notice."

The next reference to any of these species in Angus is the record of *Myosotis alpestris* in "Rep. Bot. Exch. Club, Brit. Isles" (1883), where the Rev. E. F. Linton states that the plant was gathered from the foot of wet rocks in one of the western glens of the Clova mountains, Forfar, 3rd August 1883. Two years later Buchanan White pointed out in "Journ. Bot." (1885) that he had been told by a horticultural friend that he had sown seed of *Myosotis alpestris* derived from cultivated Ben Lawers plants, along with the seeds of other alpines, in Caenlochan. "One result of this," says White, "was the discovery there, by some members of the Edinburgh Botanical Society, in 1880, of *Myosotis alpestris*, *Erinus alpinus*, *Primula auricula*, and other aliens. . . . In hope that none of the plants thus sown would have established themselves, I did not mean to put the fact formally on record; but now that *Myosotis rupicola* (*sic*) has been actually recorded, it seems necessary to mention it." The "other aliens" of Buchanan White's note are not specified, nor, in fact, are any others mentioned in the report of the excursion to which reference has been made.

So far as I have been able to ascertain *Erinus alpinus* has never been regathered in Caenlochan, but *Myosotis alpestris* was seen by Marshall and Hanbury in 1916, by MacKechnie and Wallace as recently as 1934 ("Rep. Bot. Exch. Club, Brit. Isles"), and Mr. Corstorphine informs me that he saw it in 1918, 1924, and 1927. It may be suggested, therefore, that the species has survived in Caenlochan since its introduction at least sixty years ago. There is, however, no record of *Primula auricula* having been seen during this period, but Mr. Roger's refinding of the plant last year raises the question of its possible survival during the same period of time. Only one small colony of the plant was observed occupying a wet, rather inaccessible ledge. Its associates were *Silene acaulis*, *Saxifraga stellaris*, *S. aizoides*, *S. oppositifolia*, *Sedum Rhodiola*, *Dryas octopetala*, *Trollius europaeus*, and *Angelica sylvestris*, most of which are plants of relatively damp habitats. From Mr. Roger's description of the locality it seems not improbable that he found the Primula not far from the place where it was first observed in 1880.

On a subsequent visit to Caenlochan (Aug. 1939) Mr. Roger noted several plants of Aquilegia which at the time he was not able to identify with certainty as *A. alpina*. This species, however, was reported from Caenlochan by Corstorphine in "Journ. Bot." (1916) and its status in Britain was discussed by Druce in "Rep. Bot. Exch. Club, Brit. Isles" (1916). After referring to the evidence brought forward by Buchanan White about the sowing of seeds of alpines in the Caenlochan area, Druce comes to the conclusion that *Aquilegia alpina* cannot be regarded as indigenous in Scotland.* With this view most botanists will be inclined to agree and at the same time deprecate the indiscriminate sowing of aliens in our remote highland glens, where, if they establish themselves, their discovery may perplex the field botanist of a future generation. Introduced alpines are not likely to spread far in competition with the native mountain flora, but if native species are also included, as seems to have been the case with *Myosotis alpestris*, the problem may well become more complicated. Any interference of this kind should be put on record. *Myosotis alpestris* has apparently survived in Caenlochan since its introduction sixty years ago, and it is possible that *Primula auricula* has also persisted for the same length of time, unless evidence is forthcoming that it has been introduced more than once.

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* Since this note was written Dr. M. Skalinska has discussed the problem of indigeneity of the Caenlochan *Aquilegia* in "Journ. Bot." (1940), p. 39, and reaches the conclusion that the plant should be referred to *A. pyrenaica* DC. and that it has no claim to be regarded as native in Scotland.

ON THE GERMINATION AND GROWTH OF GOODYERA REPENS.

By D. G. DOWNIE, Ph.D. (With Pls. I and II.)

(Read 16th May 1940.)

INTRODUCTION.

Goodyera repens Br. is a terrestrial orchid widely distributed in the northern regions of Europe, Asia, and North America. It is fairly abundant in the north and east of Scotland, where it is found amongst the ericaceous vegetation of pine woods and occasionally on open heathland. Germination experiments were undertaken as part of an autecological study of the plant which is being carried out by the Botany Department, Aberdeen University, and these have proved of interest in connection with the rôle of the fungus in orchid seed germination. With regard to the latter there are two opposing hypotheses: first, that of Bernard (1904, 1909), in which it is maintained that the endophytic fungus found in the roots of orchids is necessary for the germination of the seeds, *i.e.* symbiotic germination. His view entails the entry of the fungus into some of the cells of the embryo where it brings about physical and chemical changes which initiate germination. The hypothesis of Bernard is challenged by Knudson (1922, 1924), who states that "the necessity of fungus infection for the germination of orchid seeds has not been proved," and puts forward the suggestion that germination is dependent on an outside source of carbohydrate. In his opinion the orchid endophyte hydrolyses some of the insoluble carbohydrates of the humus into soluble carbohydrates, and as these become available to the seeds germination takes place. Knudson supported his thesis by a series of experiments in which, in the absence of the endophytic fungus, he germinated seeds of Laelia, Cattleya and many other orchids on sterile media containing soluble sugars + mineral salts. As there are many saprophytic fungi which hydrolyse starch into sugars, it is not surprising to find experiments described by Knudson (1925), Burgeff (1932, 1936), and Cappelletti (1935) in which orchid seed germination has been induced on a starch medium by a variety of fungi unrelated to orchid endophytes, and in which no fungus infection of the embryos has taken place. These experiments are urged in support of the non-symbiotic view of the relationship of higher plant and fungus, but in the opinion of the author they merely confirm the fact established by Knudson that the seed of many orchids germinate in sugar solutions. The experiments reported below with *Goodyera repens* tend to support the original contention of Bernard that endophytic fungi play a large, if not the whole, part in the germination of orchid seeds in the field.

GOODYERA REPENS.

Goodyera repens is a small evergreen orchid with a branching rhizomatous system terminating in rosettes of ovate leaves and bearing stout roots. It flowers in July and fruits in August and the ripe capsules contain numerous very minute brown seeds. Each seed has an elongate seed coat and generally a single undifferentiated embryo (Pl. I, fig. 1). The embryo has a comparatively large reserve of concentrated food material stored in the form of oil in all the cells except those of the meristematic region (Pl. I, fig. 2). No fungus is present in either the seed coat or the embryo.

GERMINATION EXPERIMENTS.

Germination experiments were based on the work of Knudson, and his methods were followed both with regard to seed sterilisation and the preparation of culture media. The mineral nutrient solution adopted throughout was that of Pfeffer, using potassium dihydrogen phosphate to increase the acidity.

Experiment 1. Seeds were sterilised with calcium hypochlorite and sown on agar slopes in test tubes. Although it was known that orchid seeds in general would not germinate on water or mineral nutrient solution, it was thought advisable to include these together with the sugar-containing and plant extract media recommended by Knudson. In the first experiment the seeds alone were introduced into the tubes, and, after four months, length and breadth measurements of 25 embryos from each culture medium were averaged, and the results are tabulated in Table I.

TABLE I.—SEED GERMINATED WITHOUT ENDOPHYTE ON AGAR SLOPES (4 MONTHS).

Nutrient Solution.	Average Length.	Average Breadth.	Greatest Length.	Greatest Breadth.
	mm.	mm.	mm.	mm.
Water . . .	·22	·11	·28	·15
Pfeffer . . .	·22	·11	·31	·16
Water + 2 per cent. dextrose . . .	·36	·18	·60	·27
Pfeff. + 2 per cent. dextrose . . .	·45	·23	1·02	·49
Pfeff. + 2 per cent. dextrose + pot. extract .	1·30	·48	2·14	·71
Seed soaked 24 hours .	·21	·10	·24	·13

If one compares the average size of the embryos in the soaked seeds with that on the various experimental media, it is evident that no germination has taken place in distilled water and mineral nutrient solution cultures, but in every case where sugar is present growth of the embryos is apparent. The highest percentage germination and the greatest growth of the protocorms are found where potato extract forms part of the medium.

Experiment 2. From the roots of field plants the endophytic fungus was isolated and cultured on potato dextrose agar. In general structure it is comparable to *Rhizoctonia goodyera-repentis* Constantin, isolated from *Goodyera repens* (Constantin and Dufour, 1921). Agar slopes of varying media similar to those used in Experiment 1 were sown with sterilised seed and inoculated with the endophytic fungus the following day. During inoculation great care was taken to insure that no medium was transferred from the inoculum to the seed cultures, mycelium on the walls of the tube above the medium being used as the source of infection. The results taken after four months are given in Table II.

From the measurements shown in Table II it is evident that germination has taken place on all the experimental media. The best results were obtained with Pfeffer's solution + dextrose. Those with potato extract in addition, while showing excellent results at this stage, often fail later as the protocorms cannot pierce the thick felt of mycelium.

TABLE II.—SEED GERMINATED WITH ENDOPHYTE ON AGAR SLOPES (4 MONTHS).

Nutrient Solution.	Average Length.	Average Breadth.	Greatest Length.	Greatest Breadth.
	mm.	mm.	mm.	mm.
Water . . .	·48	·27	1·31	·66
Pfeffer . . .	·64	·32	1·70	·68
Water + 2 per cent. dextrose . . .	·33	·17	·44	·24
Pfeff. + 2 per cent. dextrose . . .	1·10	·57	1·87	1·10
Pfeff. + 2 per cent. dextrose + pot. extract .	1·35	·64	2·38	1·07
Seed soaked 24 hours .	·21	·10	·24	·13

The chief interest, however, lies in the successful germination of seeds on agar slopes made with distilled water and with mineral nutrient solution. In both cases the culture medium is devoid of sugar or any other source of carbohydrate if one excludes the agar. The growth of the fungus is very slight, yet hyphae spread thinly over the agar and up the sides of the tubes. Under these conditions germination takes place and all the growing embryos examined had their basal cells infected with the fungus. As agar is a complex polysaccharide and might have proved a source of carbohydrate to the endophyte, a complementary experiment was devised to meet this contingency. A dozen test-tubes containing glass-wool and distilled water were sterilised, and sterile seed sown on the moist glass-wool. Half the tubes were carefully inoculated with the fungus. After six months the tubes were examined, and in all the infected cultures germination had taken place. Here there could be no outside source of carbohydrate, and yet a few of the protocorms were 1–2 mm. long, green-tipped, and with two or three leaf primordia initiated. The growth of fungus was as slight as in the agar cultures and all germinated protocorms were infected with the fungus. In contrast the seeds in the control tubes without the fungus showed no sign of germination.

Experiment 3. While emphasising that an outside source of available carbohydrate is fundamental for orchid seed germination, Knudson states that a second function of the endophyte is to change the hydrogen-ion concentration of the medium to that most effective in germination. To determine whether a change in the acidity of the medium was sufficient in itself to induce germination, a third experiment was set up. Weak acid and alkaline solutions of hydrochloric acid and sodium hydroxide in distilled water were made to cover a range in hydrogen-ion concentration from pH 3·6 to pH 7·6. A similar range in acidity was made with Pfeffer's solution. Glass-wool and agar were used as substrates in a duplicate series of cultures. All tubes were sterilised and sown with sterile seed, half of them were inoculated with the fungus. The results, taken six months later, were similar on the two basal solvents and on the two substrates. The figures in Table III, averaged from 30 embryos in each case, were derived from the glass-wool, distilled-water series.

TABLE III.—GERMINATION IN WATER: pH VALUE VARIABLE (6 MONTHS).

pH Values.	No Fungus.				Endophytic Fungus.			
	Average Length.	Average Breadth.	Greatest Length.	Greatest Breadth.	Average Length.	Average Breadth.	Greatest Length.	Greatest Breadth.
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
3·6	·19	·10	·26	·13	·36	·17	3·23	·85
4·4	·21	·10	·34	·17	·26	·13	1·21	·41
5·2	·21	·10	·28	·15	·30	·14	2·29	·71
6·0	·20	·10	·26	·14	·42	·19	2·04	·59
6·8	·19	·10	·26	·16	·38	·18	1·89	·61
7·6	·20	·10	·29	·16	·30	·15	1·65	·61

It will be seen from Table III that in the tubes without the fungus the average size of the embryos remains unchanged and similar to that of soaked seed. No change in the hydrogen-ion concentration of the medium, within the limits imposed, was sufficient in itself to induce germination. In all inoculated tubes, however, the average size of the embryos has increased, a few of the protocorms attaining a length of 1–3 mm. The conclusion is that symbiotic germination is unaffected by changes in the hydrogen-ion concentration of media commensurable with such fluctuations in the soil.

Seeds are to be found in the foregoing experiments in three states: (1) with infected but successfully germinated protocorms, (2) with completely parasitised embryos, and (3) with uninfected unstimulated embryos. Where a successful partnership has been established, infected cells are confined to the lower third to a half of the protocorm, active hyphae in the peripheral cells, disintegrating hyphae in the central cells. In completely parasitised embryos the defensive mechanism of the host has obviously failed, and all cells including those of the meristem are packed with active hyphae. Gradations between these two conditions are found. In addition, there are uninfected unstimulated embryos in close proximity to infected seed. These variations in the state of the embryos are found in the inoculated cultures of all experimental media. So far the greatest survival value of the orchid-endophyte association has been obtained on Pfeffer's solution with 2 per cent. dextrose.

Experiment 4. As the orchid endophyte alone stimulated germination in water, it seemed a natural corollary to suspect the fungus of supplying or inducing the production of growth-promoting substances within the cells of the embryo, thereby initiating further growth in the seed. This idea had already been subjected to experiment by Burgeff (1934, 1936) and independently by Cappelletti (1935). Successful germination of orchid seeds had been attained by these investigators on heat-killed mycelium of the endophytic fungus, on extracts from such fungi, and again on media containing such active substances as Vitamin C and members of the Vitamin B complex. To test the effect of such active substances on the seeds of *Goodyera repens*, cultures containing yeast extract, Vitamin B1, and Vitamin C were prepared. Sterilised agar slopes made with distilled water in which varying amounts of Bacto yeast extract had been dissolved were sown with sterile seed. A duplicate series using Pfeffer's solution in place of distilled water was also run. The results were similar, and Table IV shows the results of the distilled water series. The measurements are again the average of 30 embryos in each concentration, and the duration of the experiment was eight months.

TABLE IV.—GERMINATION IN SOLUTIONS OF YEAST EXTRACT (8 MONTHS).

Concentration of Yeast Extract.	Average Length.	Average Breadth.	Greatest Length.	Greatest Breadth.
	mm.	mm.	mm.	mm.
Distilled water + ·1 per cent. yeast extract .	·29	·17	·41	·22
Distilled water + ·05 per cent. yeast extract .	·25	·14	·34	·20
Distilled water + ·01 per cent. yeast extract .	·23	·11	·30	·16
Distilled water (control)	·22	·11	·31	·15

A slight increase in the average size of the embryos is apparent, showing that some stimulation to growth had been afforded. On the other hand, many of the embryos are brown and unhealthy, the yeast extract obviously having proved toxic to the seeds.

Experiments, using the pure substances Vitamin C and Vitamin B1 of the B complex, were set up in distilled water and in Pfeffer's solution on the same lines as the yeast extract experiment, but so far these have yielded negative results.

Experiment 5. The results of a series of experiments arranged to determine the most efficient sugar medium for

TABLE V.—GERMINATION IN VARYING SUGAR SOLUTIONS IN DISTILLED WATER (5 MONTHS).

Nutrient Solution.	Average Length.	Average Breadth.	Greatest Length.	Greatest Breadth.
	mm.	mm.	mm.	mm.
Distilled water + 2 per cent. dextrose	·32	·17	·93	·42
,, ,, + 1·5 ,, ,,	·31	·15	·76	·32
,, ,, + 1 ,, ,,	·45	·22	·95	·44
,, ,, + ·5 ,, ,,	·44	·21	·75	·39
,, ,, + 2 ,, levulose	·24	·12	·49	·24
,, ,, + 1·5 ,, ,,	·24	·12	·34	·16
,, ,, + 1 ,, ,,	·28	·14	·70	·36
,, ,, + ·5 ,, ,,	·29	·19	·88	·31
,, ,, + 2 ,, sucrose	·30	·15	·76	·34
,, ,, + 1·5 ,, ,,	·31	·16	·56	·25
,, ,, + 1 ,, ,,	·41	·21	·99	·36
,, ,, + ·5 ,, ,,	·25	·13	·39	·20

the aseptic germination of Goodyera seed are shown in Tables V, VI, and VII. The experiments were designed on the same lines as Experiment 1, the average measurements are of 30 protocorms, and the duration of each experiment 5 months.

TABLE VI.—GERMINATION WITH VARYING SUGAR SOLUTIONS IN PFEFFER'S MEDIUM (5 MONTHS).

Nutrient Solution.	Average Length.	Average Breadth.	Greatest Length.	Greatest Breadth.
	mm.	mm.	mm.	mm.
Pfeffer's solution +2 per cent. dextrose	·48	·26	·93	·53
,, ,, +1·5 ,, ,,	·40	·23	1·04	·46
,, ,, +1 ,, ,,	·49	·26	1·02	·56
,, ,, + ·5 ,, ,,	·43	·19	·59	·42
,, ,, +2 ,, levulose	·25	·13	·42	·24
,, ,, +1·5 ,, ,,	·23	·12	·42	·25
,, ,, +1 ,, ,,	·25	·13	·58	·36
,, ,, + ·5 ,, ,,	·35	·17	·78	·32
,, ,, +2 ,, sucrose	·30	·16	·61	·36
,, ,, +1·5 ,, ,,	·34	·18	·73	·51
,, ,, +1 ,, ,,	·34	·18	·66	·37
,, ,, + ·5 ,, ,,	·28	·14	·75	·36

TABLE VII.—GERMINATION WITH VARYING SUGAR SOLUTIONS IN PFEFFER'S MEDIUM + POTATO EXTRACT (5 MONTHS).

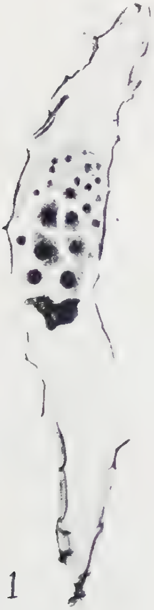
Nutrient Solution.	Average Length.	Average Breadth.	Greatest Length.	Greatest Breadth.
	mm.	mm.	mm.	mm.
Pfeffer's soln. + pot. ext. +2 per cent. dextrose	·91	·31	2·38	·93
,, ,, + ,, +1·5 ,, ,,	·70	·27	2·21	·68
,, ,, + ,, +1 ,, ,,	·88	·33	2·18	·76
,, ,, + ,, + ·5 ,, ,,	·65	·27	1·97	·66
,, ,, + ,, +2 ,, levulose	·98	·37	3·40	1·04
,, ,, + ,, +1·5 ,, ,,	·78	·25	2·63	·75
,, ,, + ,, +1 ,, ,,	·53	·17	2·38	·63
,, ,, + ,, + ·5 ,, ,,	·50	·22	1·36	·46
,, ,, + ,, +2 ,, sucrose	·68	·28	3·82	1·08
,, ,, + ,, +1·5 ,, ,,	·62	·28	2·21	·97
,, ,, + ,, +1 ,, ,,	·41	·17	1·68	·68
,, ,, + ,, + ·5 ,, ,,	·46	·22	·61	·59

Table V shows that in distilled water the weaker sugar solutions are more effective, and that on the whole dextrose solutions give the best results. In Table VI it is seen that in Pfeffer's solution all concentrations of dextrose support better growth than that obtained in any of the levulose and sucrose cultures. A comparison of Tables V and VI brings out the fact that the additional minerals of the Pfeffer's solution only very slightly enhance the germination results. On the other hand, by comparing Tables VI and VII it is at once evident that the addition of potato extract to the medium stimulates growth enormously whatever the sugar media. Table VII also brings out the fact that in a mineral nutrient solution with potato extract the higher concentrations of dextrose and levulose are the most successful, and the two sugars are almost equally effective in germination.

Three months later, re-examination of the tubes in this sugar series demonstrated even more clearly the powerful effect of potato extract on the growth of protocorms on aseptic cultures. Growth in the cultures with only the sugars or the sugars + mineral salts in solution failed to proceed beyond the 4·5 months stage, and all protocorms more than 1 mm. in length were brown and unhealthy. In contrast, growth continued steadily if slowly on all potato-extract cultures, practically all the protocorms attaining a length of 4–5 mm. on the best dextrose and levulose concentrations. The most efficient media for the aseptic cultivation of the seed of *Goodyera repens* are mineral nutrient solutions with potato extract to which 2 per cent. levulose or dextrose has been added.

EXPERIMENTS WITH THE PROTOCORMS OF GOODYERA REPENS.

Experiment 1. Two experiments were designed to show the effect of the fungus on the later life of the plant. In the first, aseptic protocorms obtained from Pfeffer's solution + 2 per cent. dextrose + potato-extract cultures were used. All were 2 mm. long, green-tipped, and with two or three leaf primordia (Pl. I, fig. 4). They were transferred aseptically to flasks containing: (1) Pfeffer's solution, (2) Pfeffer's solution + 2 per cent. dextrose, (3) Pfeffer's solution + 2 per cent. dextrose + potato extract. Half the flasks were inoculated with the orchid endophyte. After five months the plants were examined and the results are seen in Pl. II, figs. 1–5. The plants without the endophyte (1, 2, 3) increased in size



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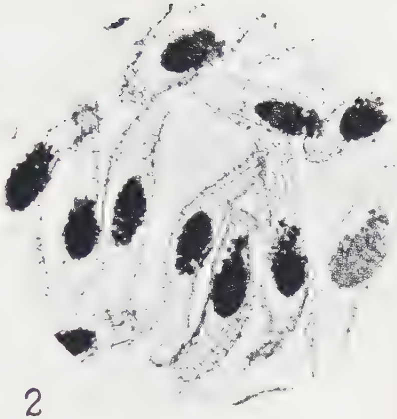

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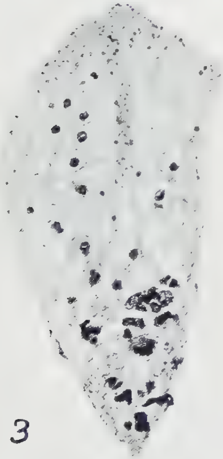

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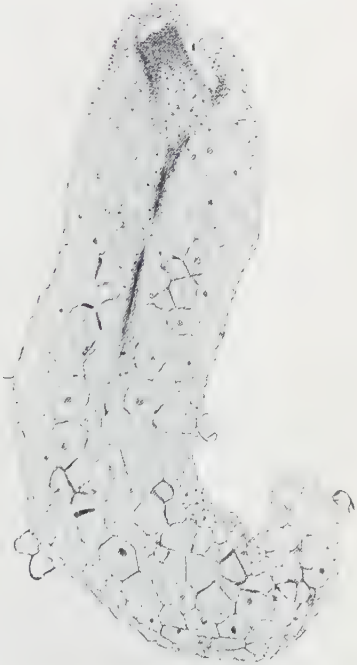

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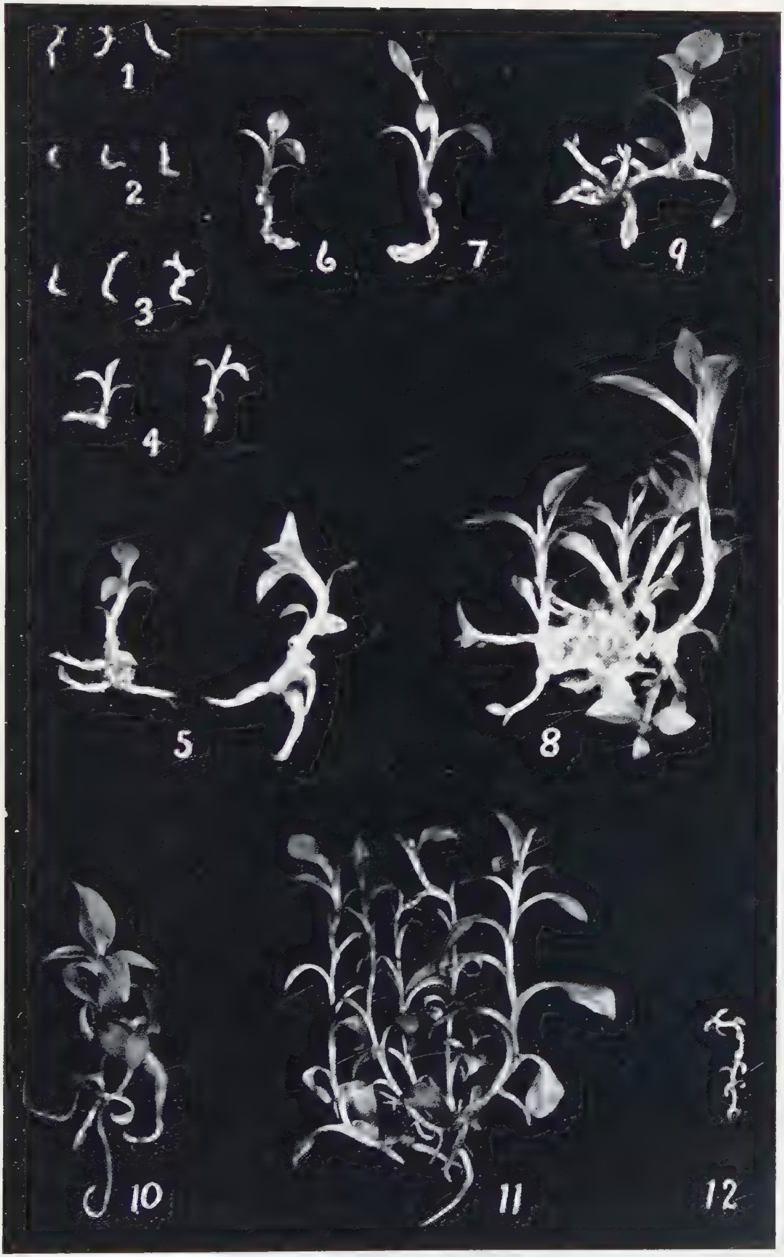
from 2 mm. to 4–5 mm., but remained slender, unbranched, with a few very small leaves and in general no roots. Of the three media, slightly better growth was obtained in the cultures with potato extract, and occasionally in these a plant developed a small root. In the cultures inoculated with the endophyte growth was stimulated considerably both in the Pfeffer's solution (4) and in the Pfeffer's solution + 2 per cent. dextrose (5), but in the flasks with potato extract in addition the small protocorms were smothered by the dense mat of mycelium. In the cultures with mineral salts and no sugar the growth of the fungus on the agar is naturally very slight, but the plants have increased from 2 mm. to 15 or 20 mm. They are slender, the rhizome is unbranched, the leaves are small but of good green colour, and a stout root is usually developed (Pl. II, fig. 4). Where sugar is also present in the medium, the fungus soon forms a thin white covering over the agar and the plants increase from 2 mm. to 3 or 4 cm. These plants (Pl. II, fig. 5) have stout well-branched rhizomes bearing one or two strong young roots, and the rosettes of leaves are fairly comparable in size and colour to that of young shoots of field plants. The most natural growth of these originally aseptic protocorms was obtained on a medium containing mineral nutrient salts, a sugar and the endophyte, but even without the soluble carbohydrate stimulation due to the endophyte alone is remarkable. Almost invariably infection of the plantlets follows the introduction of the endophytic fungus, but, in one of the cultures containing Pfeffer's solution only, a protocorm remained uninfected. Its growth lagged far behind that of the infected plants in the same flask. In development it was exactly comparable to the aseptic plantlets on the same medium in the uninoculated series.

Experiment 2. A second experiment was set up to determine which concentration of dextrose in Pfeffer's solution is the most favourable for the growth of protocorms infected from the seed stage by the fungus. The infected protocorms were all 2–3 mm. long, green-tipped, and with a few leaf primordia, when transferred to flasks containing Pfeffer's solution and the following concentrations of dextrose: (*a*) no sugar, (*b*) ·5 per cent., (*c*) 1 per cent., (*d*) 2 per cent. After 5 months the plants were examined, and the variation in growth may be judged from Pl. II, figs. 6–9. Where the sugar content is nil or only ·5 per cent. the plants—(6) and (7)—are comparatively small and their rhizomes remain unbranched. Where the concentration is raised to 1 per cent. the plants (8) develop numerous shoots and roots and the maximum growth is obtained. A further increase in sugar produces sturdy little plants with fewer shoots (9).

A few of the flasks from Experiments 1 and 2 were left undisturbed for a period of 15 months. Three plants were then photographed as the relative growth on the different media was even more marked (Pl. II, figs. 10–12). The first of these (10) is on a mineral nutrient solution with the endophyte, no sugar is present, yet the plant is very healthy, the leaves are a good green colour, the rhizome bears one shoot and four roots, and in all the plant is quite comparable to a small-leaved field plant. Plant (11) has grown with the endophyte on Pfeffer's solution and 1 per cent. dextrose. Here the rhizome bears many shoots and many roots, the leaves are slightly smaller and the shoots more upright than in field specimens, but the whole plant is healthy and vigorous. Plant (12) is grown on the same medium as (11), but in the absence of the endophyte; the difference in growth is exceedingly great. Without the endophyte the plant is small, slender, unbranched, with short stunted internodes and no roots.

DISCUSSION.

Symbiosis is described as the living together of dissimilar organisms with benefit to one only or to both. The roots of orchids are constantly infected with an endophytic fungus, and many believe that a state of symbiosis here exists in which the orchid benefits by the association. The first beneficial effect is said to occur at germination where, according to the proponents of the symbiotic theory, growth of the seed will not take place unless the embryo is infected by the fungus. Those who oppose the symbiotic theory claim that germination is due, not to direct attack by the endophytic fungus, but to changes in the external medium caused by saprophytic fungi which may or may not include the orchid endophyte. The changes referred to are, first and most important, the production of sugars on the hydrolysis of the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starch components of the humus; second, the alteration of the hydrogen-ion concentration; and third, the secretion of enzymes and the accumulation of autolytic substances in the surrounding medium.

It is difficult to dissociate fungi which are heterotrophic plants from an organic substrate, but it is believed that this has been accomplished for a period long enough to fulfil the requirements of experiments. Mycelium cultured on a rich medium, develop fine hyphae in water cultures which are sufficient to induce the germination of seeds of *Goodyera repens*. No soluble carbohydrate is present in the medium.

That the very slight growth of hyphae in these water cultures may produce local changes in hydrogen-ion concentration cannot be denied, but the negative growth results obtained in uninfected water and mineral nutrient cultures of varying acidity tend to minimise the importance of this environmental condition where seed germination is concerned. Finally, autolytic substances and enzymatic secretions from the hyphae are without doubt present in the infected water and Pfeffer solution cultures. It is difficult to ascertain whether their presence in the medium stimulates germination or not, but it seems reasonable to assume that such products of the mycelium, if they do promote growth, would be even more effective within the host cells than without. Indirect proof that such substances do not stimulate germination is forthcoming on the examination of numerous embryos from the infected water cultures. No growing embryos were found which were not infected by the endophytic fungus. A further proof of the negative value of such substances as growth promoters may be deduced from one of the protocorm experiments described above. Here it will be remembered that of the six aseptic protocorms introduced into a flask containing Pfeffer's solution agar and the endophyte, one remained uninfected and its growth lagged behind that of the other five. The growth of the uninfected protocorm appeared no greater than that obtained by aseptic protocorms on an uninfected mineral nutrient agar.

From a consideration of the above it is therefore thought that a true symbiotic germination of the seeds of *Goodyera repens* has been demonstrated. It will be interesting to discover whether the seeds of many orchids can be stimulated to germinate in water with the help of the appropriate endophytic fungus.

Further, it is held that germination of the seeds of *Goodyera repens* in the field may be more frequently initiated by fungus infection than by the absorption of soluble sugars. Marked areas in a pine wood in which there are many Goodyera plants were sown very densely with seeds just after the ripening of the capsules. These areas were obviously supporting many saprophytic fungi. Whether there were amongst them any capable of hydrolysing insoluble carbohydrates to soluble carbohydrates was unknown, but as this is an attribute of many of the commoner soil fungi it was hoped that germination might be obtained even if the orchid endophyte was absent from the area. A number of these areas were examined and the experiments repeated over two years, yet no protocorms were found. Field protocorms were first obtained by Miss J. Mollison while examining a clump of plants brought into the laboratory. Since then many have been found in the pine woods and on the moors, but with one possible exception all were in close proximity to adult plants. All field protocorms have their basal cells infected by a fungus.

The supporters of the symbiotic theory further maintain that in the later life of the orchid beneficial results accrue to the host from its association with the fungus. It is important to realise that the degree of dependence of the various orchids on their appropriate endophytic fungi may be very variable in the different genera and species. When the critical period of germination is over it is conceivable that many green-leaved orchids may prove completely autotrophic as demonstrated experimentally for Laelia and Cattleya by Knudson. *Goodyera repens* does not fall into this category. Aseptic protocorms on a mineral nutrient solution make poor progress; the addition of the endophytic fungus greatly stimulates growth. That agar is present in the experimental medium hardly affects the results. It is known to be extremely low in nutritive value, and any change in the external environment effected by the very slight growth of mycelium on the agar must be negligible. Comparable results are obtained on sugar-containing media, with an even more striking contrast in the growth of infected and non-infected plants. These facts can only be interpreted on the assumption that a true state of symbiosis exists in which the orchid definitely benefits by the association.

At present the most acceptable view of the fungus in a mycorrhizal association is that of a facultative saprophyte attempting to parasitise orchid embryos or adult plants, and being successfully controlled, in the majority of cases, by the defensive mechanism of the host (Burges, 1936). In the subsequent digestion of the hyphae in the host cells, I think that substances are released which are extremely active in stimulating growth both at germination and in the later life of the plant.

SUMMARY.

Aseptic germination of the seeds of *Goodyera repens* Br. takes place readily in weak sugar solutions in water. Germination results are slightly enhanced by the addition of the essential mineral elements. Growth, however, soon ceases in both the above culture media.

Germination is improved and growth greatly increased if potato extract forms part of the nutrient salt and sugar medium. Levulose and dextrose produce better results than sucrose. A slow growth can be maintained on such a medium.

No germination was obtained on distilled water or mineral nutrient solution with hydrogen-ion concentration ranging from 3·6 to 7·6.

In the presence of the endophytic fungus and water, no outside source of carbohydrate is necessary to stimulate germination, *i.e.* the symbiotic germination of the seeds of *Goodyera repens* has been accomplished.

Germination results in inoculated cultures are considerably improved if sugar and mineral salts are present in the medium.

Weak concentrations of yeast extract in water or in Pfeffer's solution stimulate germination, but prove toxic to the embryos.

Aseptic green protocorms grow very slowly on Pfeffer's solution even when sugar and potato extract are present.

Similar protocorms when grown in flasks inoculated with the endophytic fungus are greatly stimulated on media with and without sugar.

Infected protocorms grow successfully on a mineral nutrient

medium alone, but growth is greatly invigorated if sugar is also present in low concentrations in the medium.

ACKNOWLEDGMENT.

Thanks are due to the Carnegie Trust for a grant towards the cost of apparatus in aid of the present research.

REFERENCES.

BERNARD, N. (1899): Sur la germination du Neottia Nidus-Avis. Compt. Rend. Acad. Sci. Paris, cxxviii, 1253–1255.

—— (1904): Recherches experimentales sur les Orchidees. Rev. Gen. Bot., xvi, 405–451, 458–476.

—— (1909): L'evolution dans la symbiose. Les Orchidees et leur champignons commensaux. Ann. Sci. Nat. Bot., Sér. 9, ix, 1–96.

BURGEFF, H. (1909): Die Wurzelpilze der Orchideen, ihre Kultur und ihr Leben in der Pflanze. Jena.

—— (1911): Die Auzucht tropischer Orchideen aus Samen. Jena.

—— (1932): Saprohytism und Symbiose. Jena.

—— (1934): Pflanzliche Avitaminose und ihr Behebung durch Vitaminzufuhr. Ber. Deut. Bot. Ges., lii, 384–390.

—— (1936): Samenkeimung der Orchideen. Jena.

BURGES, A. (1936): On the significance of Mycorrhiza. New Phyt., xxxv, 117–131.

CAPPELLETTI, C. (1935 *a*): Osservazioni sulla germinazione asimbiotica e simbiotica di alcune orchidee. Nuovo Gior. Bot. Ital., xlii, 436–457.

—— (1935 *b*): Ulteriori Osservazioni sulla germinazione asimbiotica di Cymbidium. Nuovo Gior. Bot. Ital., xlii, 685–690.

CONSTANTIN, J., and DUFOUR, L. (1920): Sur la biologie du *Goodyera repens*. Rev. Gen. Bot., xxxii, 529–533.

CURTIS, J. T. (1939): The Relation of Specificity of Orchid Mycorrhizal Fungi to the Problem of Symbiosis. Amer. Journ. Bot., xxvi, 390–399.

KNUDSON, L. (1922): Nonsymbiotic Germination of Orchid Seeds. Bot. Gaz., lxxiii, 1–25.

—— (1924): Further Observations on Nonsymbiotic Germination of Orchid Seeds. Bot. Gaz., lxxvii, 212–219.

—— (1925): Physiological Studies of the Symbiotic Germination of Orchid Seeds. Bot. Gaz., lxxix, 345–379.

—— (1930): Flower Production by Orchid Grown Nonsymbiotically. Bot. Gaz., lxxxix, 192–199.

RAMSBOTTOM, J. (1922): Orchid Mycorrhiza. Trans. Brit. Mycol. Soc., viii, 28–61.

EXPLANATION OF PLATES.

Plate I.

Fig. 1.—L.S. seed of *Goodyera repens* Br. ×120.
Fig. 2.—Seeds stained with Sudan III. ×50.
Fig. 3.—Infected protocorm (3 months) germinated in water. ×46.
Fig. 4.—Aseptic protocorm (4 months) germinated in Pfeffer's solution +2 per cent. dextrose + potato extract. ×42.

Plate II.

Figs. 1–5.—Relative growth of aseptic and inoculated plants (5 months). All were 2 mm. long and aseptic at commencement of experiment. 1, 2, 3, kept aseptic; 4 and 5, inoculated with endophytic fungus; 1 and 4, Pfeffer's solution; 2 and 5, Pfeffer's solution + 2 per cent. dextrose; 3, Pfeffer's solution + 2 per cent. dextrose + potato extract. $\times \frac{4}{5}$.
Figs. 6–9.—Relative growth of infected plants on varying concentrations of dextrose dissolved in Pfeffer's solution (5 months). All were 2 mm. long when transferred. (6), no sugar; (7), ·5 per cent.; (8), 1 per cent.; (9), 2 per cent. $\times \frac{4}{5}$.
Figs. 10–12.—Relative growth of aseptic and infected plants (15 months). All were 2–3 mm. long at commencement of experiment. 10 and 11 are both infected. (10), Pfeffer's solution; (11), Pfeffer's solution + 1 per cent. dextrose; (12), not infected by endophytic fungus and on same medium as 11. $\times \frac{2}{5}$.

NOTES ON THE BOTANY OF NORTH RONA AND SULA SGEIR.

By ROBERT ATKINSON. (With Two Maps.)

(Read 20th June 1940.)

1. NORTH RONA.

The only published account of the botany of North Rona, that of R. M. Barrington, is now over fifty years old. Barrington's list, compiled during a visit to the island on 1st July 1885, was printed in Harvie-Brown's "Further Notes on North Rona" (Proc. Roy. Phys. Soc. Edin., ix, Pt. 1, 1885, p. 289) and prefixed with the remarks: "I was too early; but the flora is remarkable for its poverty; *Plantago maritima* absent, and *Ophioglossum vulgatum* var. *ambiguum* abundant. These are the two salient points. I noticed 35 species, to which a few might be added later on."

A month's stay on Rona in July–August 1936 gave an opportunity of studying the botany of the island in the light of Barrington's list. I am indebted to Mr. H. Gilbert-Carter of the Cambridge Botany School, and to Mr. F. R. Makins, for the identification of several specimens; to Mr. T. Naish for the map of Rona.

SYSTEMATIC LIST.

Of Barrington's list of thirty-five species recorded in 1885, the following were again recorded in 1936:—

Ranunculus Flammula Linn.
Ranunculus repens Linn.
Cochlearia officinalis Linn.—R. M. B. also recorded *C. officinalis* var. *alpina.*
Sagina maritima Don—R. M. B. also recorded *S. procumbens* Linn.
Cerastium triviale Link—R. M. B. also recorded *C. tetrandum* Curt.
Stellaria media With.
Montia fontana Linn.

Trifolium repens Linn.
Potentilla Anserina Linn.
Hydrocotyle vulgaris Linn.
Ligusticum scoticum Linn.
Angelica sylvestris Linn.
Bellis perennis Linn.—Two specimens only seen in 1936.
Matricaria inodora Linn.
Leontodon autumnalis Linn.
Glaux maritima Linn.
Plantago coronopus Linn.
Armeria maritima Willd.
Atriplex Babingtonii Woods.
Rumex Acetosa Linn.
Eriophorum angustifolium Roth.
Eleocharis palustris R. Br.
Carex vulgaris With.
Holcus lanatus Linn.
Nardus stricta Linn.
Festuca rubra Linn.
Poa pratensis Linn.
Ophioglossum vulgatum Linn.—R. M. B. gave the variety as *ambiguum.*

The following twelve new records for North Rona were added in 1936:—

Spergularia salina Presl.
Achillea Millefolium Linn.—A single specimen in village graveyard.
Euphrasia officinalis Linn.—Rare; only at top of western cliffs.
Atriplex (?) patula Linn.
Rumex crispus Linn.—Rare.
Rumex obtusifolius Linn.—Rare.
Polygonum aviculare Linn.
Juncus lamprocarpus Ehrh.
Juncus bufonius Linn.
Agrostis stolonifera Linn.
Poa annua Linn.—Locally abundant.
Sieglingia decumbens Bernh.

The following four species recorded by Barrington were not found in 1936. They must be by now either extinct or extremely scarce:—

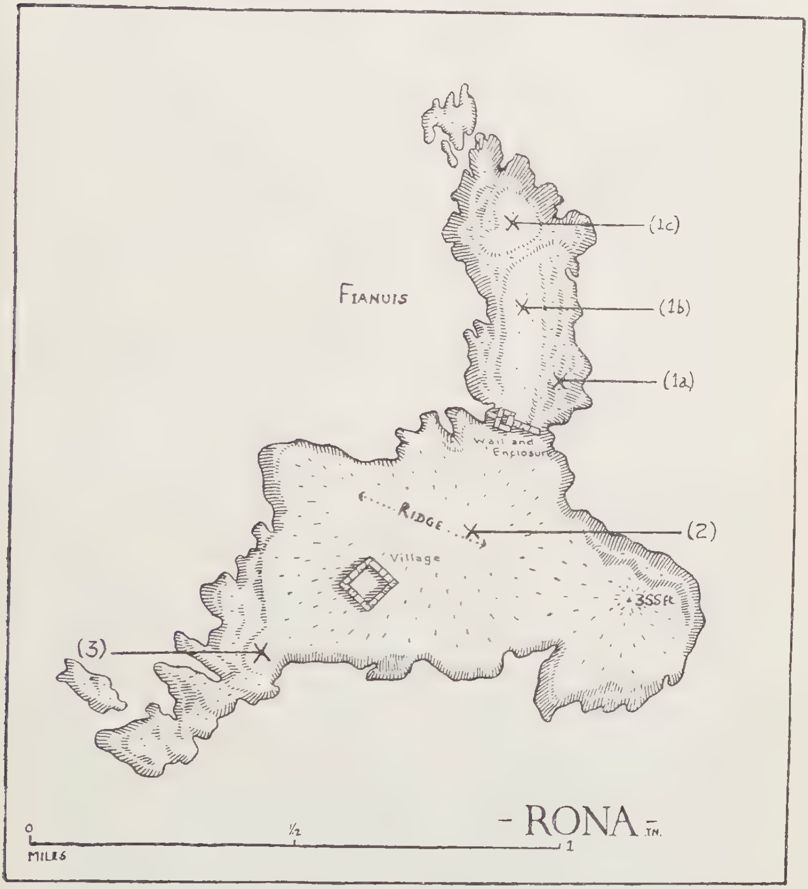
Plantago major Linn.
Rumex Acetosella Linn.
Luzula (*campestris* DC.?)
Aira praecox Linn.

DISTRIBUTION.

The island falls easily into four topographical divisions. each with a characteristic vegetation. These divisions are: (1) Fianuis, the northerly peninsula, low and rocky; (2) the inland ridge with its steep northerly and gentle southerly slopes, including the ruins of the village; (3) the south-west peninsula, similar in appearance to Fianuis, but of quite different vegetation; (4) the cliffs. The description of the vegetation applies to 1936 and is intended as a basis for future comparison. If a description had been made in 1885 it would now be of great interest, and considerable changes could certainly have been observed against such a control. The only human factor, and that indirect, now operating to modify the vegetation of the island, is the flock of about 200 sheep which is left unattended all the year round.

(1) *Fianuis.*—The basic vegetation of Fianuis is given by *Armeria*. The eastern half of Fianuis (Map, 1*a*) was evidently once entirely covered with *Armeria*, which now only grows at the extreme edge of the area. The soil of this area consists of a dry "peat" formed exclusively from dead *Armeria* clumps. A succession from bare earth, of which several patches remain, now appears to be taking place, the colonizing species being *Poa annua*, *Atriplex*, and *Stellaria media*. What has caused the dying off of the *Armeria* it is impossible to say. Puffins may conceivably have so burrowed amongst its roots, as has happened elsewhere, that it has all died; the puffin burrows would soon have fallen in. Fianuis is a great breeding-ground of grey seals; the tenant of Rona asserts that the oil from the seals' coats, when the seals come ashore to calve in the autumn, destroys the vegetation. Supposing that seal oil originally destroyed the *Armeria*, which seems unlikely, it is surprising that the replacing *Poa*, *Atriplex*, and *Stellaria* should be un-

affected; all these three, however, are annuals which must die down before the seals come ashore, whereas *Armeria* is perennial. If the seals were a factor, the first establishment of *Armeria* is problematical. It seems most likely that puffins first honeycombed the *Armeria*, and that the weight of seals' bodies then broke down the tunnels.



The *Atriplex* is much burnt by salt winds, but the *Poa* and *Stellaria* are unaffected. *Poa annua* is, in fact, the most interesting plant of the Rona flora. It is new since 1885; its seeds must have reached Rona in the hooves of sheep, at the annual exchange of sheep between Rona and the Mainland of Lewis. It has spread rapidly from the sheep landing-place and sheep fank, northwards into Fianuis where, as already stated, it is a large constituent of the plants now colonizing the "*Armeria*-peat." Its frequency is, however, still greatest about the sheep fank, where it forms a considerable, exclusive, closed community.

The western side of Fianuis (Map, 1*b*) is a flat higher ground, covered with a short turf of, chiefly, *Festuca*, *Armeria*, and *Plantago*. An island of vegetation in the northern part of Fianuis (Map, 1*c*) is surrounded by rock, and consists of *Armeria*, *Atriplex*, *Stellaria*, *Matricaria*, and *Poa*; the *Poa* is thickest in and beside the sheep tracks. At the edges of this area grows only *Armeria*, on otherwise bare rock. Bare rock surrounds all the peninsula of Fianuis, except at its narrow base.

(2) *The Inland Ridge.*—The north slope of the ridge is steep and dry, the south slope gradual and wet. *Holcus lanatus* makes a thickly grassed meadow of much of the north slope, though near the bottom *Armeria* clumps appear in the grass, and at the western edge *Plantago* often forms a very close, exclusive "turf." There is no "thrift line" on Rona: *Armeria* is to be found far from the sea, and from nearly sea-level to the highest parts of the land.

On the ridge itself *Nardus stricta* occurs in exclusive patches, as does *Holcus*, with a thick mat of dead grass below the stems: in wetter places *Eriophorum angustifolium* is exclusive. These three species, with *Carex vulgaris*, make up the coarse grass and sedge pasture which covers the flat top of the ridge. In the several shallow, stagnant pools along the ridge *Ranunculus Flammula*, *Sagina maritima*, and *Ophioglossum* are common. There is no actual stream on Rona, but damp tracts on the south slope may show a thin trickle after rain. In these places *Ophioglossum* is abundant, with *Montia*, *Hydrocotyle*, *R. Flammula*, and *Angelica*.

The lower part of the south slope is covered with a less rank herbage; *Festuca*, *Rumex Acetosa*, *Cerastium triviale*, and *Holcus* are large constituents. The ruins of the village are overgrown with these species, and in addition with *Potentilla*, *Stellaria*, and *Armeria*. *Potentilla* is practically confined to the village, where it is locally exclusive; *Stellaria* often makes a thick exclusive carpet over the floors of the ruins. *Armeria* appears first to colonize the stone walls, and later to be replaced by a *Festuca-Cerastium* turf. *Trifolium repens* and *Ranunculus repens* occur sparsely about the village in the cultivation ridges which still persist; *Trifolium* in particular grows nowhere else, and both will probably eventually disappear, as *Plantago major* appears already to have done and *Bellis perennis* is on the verge of doing. These four species, no doubt, originally reached Rona as weeds or plants of cultivation; and now, cultivation or intensive grazing having long since ceased, are being gradually choked out.

(3) *The South-West Peninsula.*—This area, topographically similar to Fianuis, bears a very different vegetation, though *Armeria* as a basis is common to both. The vegetation leaves no bare patches as on Fianuis, being a close seaside turf of *Festuca*, *Armeria*, *Plantago*, *Matricaria*, *Leontodon*, and *Cerastium*. *Matricaria*, particularly in the southern part, and *Leontodon* are locally dominant. *Atriplex*, *Stellaria*, and *Poa annua* do not occur.

(4) *The Cliffs.*—The wetter parts of the cliff slopes show a luxuriant vegetation of *Rumex Acetosa*, *R. obtusifolius*, *Angelica*, and *Cochlearia officinalis*. In places *Cochlearia* grows to enormous size in trailing clumps on the wet cliff face. *Ligusticum* is practically confined to the high cliff-tops at either end of the ridge, while *Angelica*, with the exception of a few stunted cliff-top specimens, grows only where wet tracts lead down the cliffy slopes.

2. SULA SGEIR.

No list of the plants of Sula Sgeir—the big sea rock with its gannetry, twelve miles west of Rona—was published until 1933, when Malcolm Stewart listed five species collected during the previous summer (Ronay. London, 1933, p. 46). The five species are:

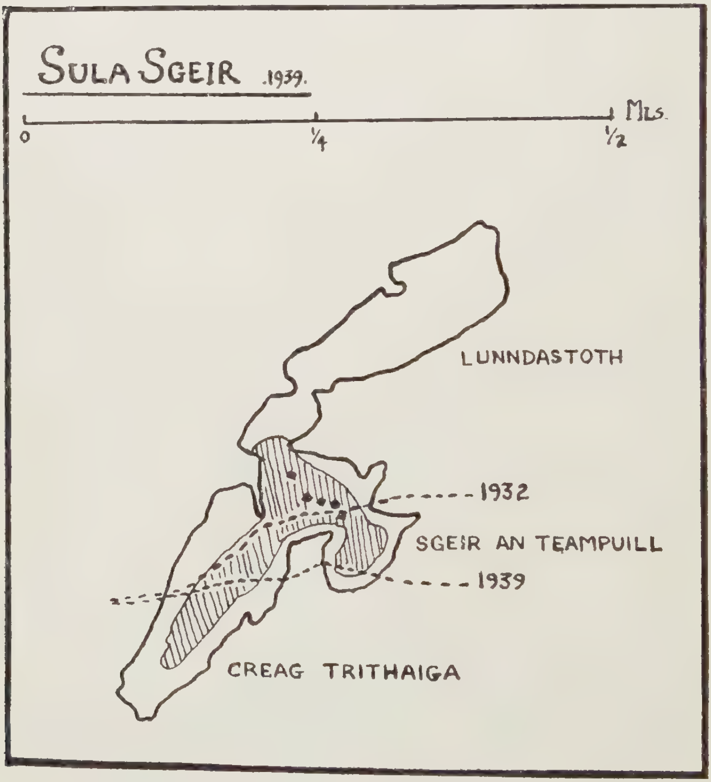
Cochlearia officinalis Linn.
Stellaria media With.
Matricaria inodora Linn.
Armeria maritima Willd.
Atriplex (?) *Babingtonii* Woods.

A visit to Sula Sgeir on 3rd and 4th August 1939 showed that considerable changes in the distribution of the vegetation had taken place during recent years, and two further species were recorded, viz:

Spergularia salina Presl
Poa annua Linn.

DISTRIBUTION.

Sula Sgeir is a ridge of rock, almost exactly half a mile long and rising to a greatest height of 229 feet near the southern extremity; a constriction of height and width near the middle almost divides the island into two.


SULA SGEIR .1939.
0
¼
½
MLS.
LUNNDASTOTH
1932
SGEIR AN TEAMPUILL
1939
CREAG TRITHAIGA

- - - - - = Northern limits of gannets. Shaded area = Area of green. Dots = Bothies. (1932 line mapped by M. Stewart.)

Lunndastoth, the part north of the narrow neck, is to all intents bare and has no trace of soil, though occasional plants of *Atriplex*, *Armeria*, and *Cochlearia* can be found. Sea-birds have evidently never bred there in such numbers as would have formed a soil debris sufficient for the establishment of colonizing plants. Whereas in 1939 only seven pairs of fulmars bred on Lunndastoth, 603 nests were counted on the southern part of the island. Practically all the life of the island, both bird and plant, is confined to this southern part, which rises steeply from the neck and divides into two branches —Sgeir an Teampuill to the south, and Creag Trithaiga to the south-west.

Some half-dozen bothies remain in the centre of the island. Around them *Matricaria*, *Armeria*, *Atriplex*, *Stellaria*, and *Poa* make a green "turf," with *Matricaria* dominant. The soil is a peaty guano, no more than a thin skin laid over the rock. The gannetry is now confined to the southern ends of the two branches; green vegetation extends in patches to the very edge of the gannetry and to the highest points of both peninsulas. The vegetation of Sgeir an Teampuill consists almost exclusively of *Armeria* and *Atriplex*, while the greater part of Creag Trithaiga is covered with *Armeria* alone. Much of this latter exclusive cover of *Armeria* consists of mushroom-shaped tussocks, overgrown from the richness of the soil, and hardly flowering. These tussocks nearly touch each other and rise on columns a foot and more high.

SUCCESSION.

During the last few years the area occupied by nesting gannets has considerably decreased. As they have retreated southwards, away from the centre of the island, they have left areas of rich soil of organic debris, which has been quickly colonized by vegetation and as soon occupied by other nesting sea-birds, particularly puffins, fulmars, and Leach's petrels. Thus of 1932 Malcolm Stewart wrote that "Vegetation . . . is only to be found at all around the buildings" and that the number of fulmars "probably does not exceed 150 pairs" (Ronay, pp. 45–46). In 1939 all the southern part of the island, except for cliff, soilless rock, or gannetry, was green, and the number of fulmars had risen to over 600 pairs. The lines marking respectively the northern limits of gannetry in 1932 and 1939 are shown on the map. Puffins appear to have decreased since 1932, and at present little ground is open to them for nesting; most of the few remaining breed under boulders.

It is probable that *Armeria* has been the first colonist of the bare soil left behind retreating gannets, and has quickly made an exclusive cover. The mushroom tussocks may conceivably be a vegetative overgrowth due only to the richness of the soil; more probably they are the result of the burrowing in original *Armeria* turf by nesting puffins; the decrease in the number of puffins supports this, they being presumed to have destroyed their one-time nesting warren. In any case the puffin population must have made an increase and then a greater decrease between 1932 and 1939, because the present area of tussock *Armeria* was in 1932 covered by gannets. What will succeed the *Armeria* remains to be seen.

In areas of thinner soil—Sgeir an Teampuill and the north part of Creag Trithaiga—*Atriplex* is commonly dominant, though associated with *Armeria*; they appear to have been associated as original colonists. *Cochlearia*, *Stellaria*, and *Poa* join these species on older ground, until, around the area of the buildings, the full flora grows as a turf, in which *Matricaria* is dominant.

LIST OF ALGAE FOUND IN BOGHALL GLEN.

By E. WYLLIE FENTON, M.A., D.Sc.

(Read 20th June 1940.)

In an extensive area such as the Glen at Boghall Farm it is obvious that sampling methods, however carefully devised, cannot hope to succeed in revealing the presence of those algae which are not plentiful or of common occurrence. Another difficulty is the constant change in course of streams and ditches. New ditches are opened up from time to time for drainage purposes, and this affects not merely the new area, but may drain off water from previously existing ditches. The natural fall in level also tends in time of flood to wash away many algae and to scour the beds of the streams and ditches. Within recent years the successful introduction of cattle to the Glen, to keep down the rough vegetation, has affected algal growth. Drainage ditches are broken or destroyed, while many of the wells and sources of water have been severely puddled. The result is that many algae have disappeared and some have become relatively scarce. It is desirable that those algae found and identified should be recorded for future reference. Bacilliares (Diatomales) have not been investigated.

The classification adopted is that of Fritsch in "British Fresh-water Algae," by West and Fritsch (1927).

CLASS ISOKONTAE.

GROUP VOLVOCALES: Series Chlamydomonadales: Chlamydomonas Debaryana; Brachiomonas submarina.

Series Tetrasporales: Palmella mucosa; Palmodictyon varium; Sphaerocystis Schroeteri; Asterococcus superbus; Gloeocystis gigas; Dactylothece Braunii; Schizochlamys gelatinosa; Tetraspora gelatinosa.

GROUP CHLOROCOCCALES: Pediastrum Boryanum, P. tetras, P. duplex; Chlorella vulgaris; Dactylococcus bicaudatus; Ankistrodesmus falcatus.

GROUP ULOTRICHALES: Ulothrix zonata, U. subtilis, U. variabilis; Hormidium flaccidum; Microspora amoena, M. floccosa, M. stagnorum, M. pectinata (?); Prasiola crispa; Rhizoclonium hieroglyphicum; Cladophora glomerata, C. crispata.

GROUP CHAETOPHORALES: Stigeoclonium tenue; Draparnaldia plumosa; D. glomerata; Gongrosira terricola, G. viridis (?); Chaetosphaeridium globosum; Pleurococcus Naegelii.

GROUP OEDOGANIALES: Oedogonium rufescens, O. cyathigerum.

GROUP CONJUGATAE: Series Eu-conjugatae: Roya obtusa; Zygnema insigne, Z. anomalum, Z. pectinatum; Spirogyra majuscula, S. gracilis, S. nitida, S. tenuissima, S. varians, S. affinis, S. communis; Sirogonium stiticum; Mougeotia gracillima, M. parvula, M. scalaris, M. genuflexa, M. capucina; Zygogonium ericetorum.

Series Desmidiaceae: Closterium acutum, C. gracile, C. acerosum, C. Ehrenbergii, C. Leibleinii; Tetmemorus granulatus; Micrasterias denticulata; Cosmarium Cucurbita, C. Ralfsii.

GROUP SIPHONALES: Vaucheria terrestris, V. sessilis, V. hamata.

CLASS HETEROKONTAE.

GROUP HETEROTRICHALES: Tribonema bombycinum, T. Raceborskii (C. A. Ag.) Derby & Sol; Bumilleria exilis.

CLASS DINOPHYCEAE.

Ceratium cornutum (recorded twice); Peridinium cinctum (recorded once).

CLASS EUGLENINEAE.

Euglena viridis, E. acus, E. tripteris (?); Lepocinclis ovum.

CLASS RHODOPHYCEAE.

Batrachospermum moniliforme; Lemanea mamillosa.

CLASS MYXOPHYCEAE (Cyanophyceae).

GROUP CHLOROCOCCALES: Gloeothece confluens, Aphanothece microscopica; Synechococcus aeruginosus, Eucapsis alpina (recorded once), Microcystis stagnalis, M. flos-aquae; Aphanocapsa Grevillei.

GROUP HORMOGONEALES: Oscillatoria limosa, O. irrigua, O. proboscidea; Phormidium Retzii, P. tenue; Nostoc muscorum, N. coeruleum, N. commune; Anabaena oscillarioides, A. inaequalis, A. flos-aquae; Aphanizomenon flos-aquae (a few records); Cylindrospermum stagnale, C. muscicola (?); Nodularia Harveyana; Rivularia haematites (?), Gleotrichia natans; Stigonema minutum (?).

Naturally several of the algae recorded are not common and the exact specific identification of those marked "?" is a little doubtful. The solitary occurrence of three specimens of the rare *Brachiomonas submarina* is interesting. This species is recorded as marine or of brackish water areas. Fritsch (1927, p. 71) remarks "has been recorded from freshwater habitats." This species has been critically considered by West (1908), Tozer (1908), and Neilson-Jones (1922). Its presence in Boghall Glen water suggests contamination, probably by some sea-gulls or bird visitors from the shore areas of the Forth Estuary. The alga was only found once, on one slide, and never again observed. *Ceratium cornutum* was found only twice. *Mougeotia capucina* was identified once. *Microcystis flos-aquae*, *Gleocapsa magna*, *Stigonema minutum*, *Euglena tripteris*, *Gongrosira viridis*, *Rivularia haematitis*, and *Aphanizomenon flos-aquae* were also of rare occurrence in cultures. Whether these algae are rare species occurring in Boghall Glen or contamination from other sources is a question difficult to decide. As Boghall Glen is virtually never used for sporting purposes, it is often visited by birds and other animals which may quite easily introduce algae not typically occurring in the Glen. Some algae may therefore be introduced periodically and survive. Others may be introduced very rarely and fail to survive after introduction. *Brachiomonas submarina* probably belongs to the latter category.

It is not possible to give any accurate indication of the relative abundance of the various species. This was pointed out in the first publication on this subject [Fenton (1936)]. Many forms and species have been found in a condition in which identification was not possible. Several species were found only in laboratory cultures [Fenton (1940)], and not by sampling methods in Boghall Glen. Myxophyceae in Boghall Glen are comparatively rare. It was only in cultures of soil, etc., that any progress was made, and the fact revealed that they did occur. This absence of Myxophyceae may be linked up with the absence of nitrogen in a suitable form, and of available organic matter. The fact that *Oscillatoria* spp. occurred sparingly in recently cultivated plots in Boghall Glen is rather significant [Fenton (1940)]. There is little doubt that had cultures been made such as those by Bristol and Roach (1927), the number of algae might have been considerably increased. The chief aim in the present work, however, is a consideration of these algae which occur under natural conditions, or under conditions of culture which follow natural conditions as closely as is possible in a laboratory. The rather high temperature and still water in cultures greatly assisted types like Euglena, Chlamydomonas, and the Myxophyceae. Closterium, Cosmarium, and certain other algae were usually found either when Sphagnum spp. was examined or in cultures.

REFERENCES.

BRISTOL, B. M., and ROACH, W. A., 1927: On the Algae of Some Normal English Soils. J. agric. Sci., xvii, pp. 563–588.

FENTON, E. WYLLIE, 1936: The Periodicity and Distribution of Algae in Boghall Glen (Midlothian). Scot. Nat., pp. 143–148.

——, 1940: Algae Studies from Boghall Glen (Midlothian)—VI. Culture Series No. 2. Edinburgh and East of Scotland College of Agriculture.

FRITSCH, F. E., and WEST, G. S., 1927: A Treatise on the British Fresh-water Algae. Cambridge.

NEILSON-JONES, W., 1922: Note on the Occurrence of Brachiomonas sp. Proc. Linn. Soc. Lond. (134 Session), pp. 57–59.

TOZER, E., 1908: Brachiomonas submarina, Bohlin. J. Roy. Micr. Soc., Pt. 5, pp. 551–553.

WEST, G. S., 1908: Some Critical Green Algae. J. Linn. Soc. Lond. (Bot.), xxxviii, pp. 279–289.

DESCRIPTIONS OF NEW FUNGI CAUSING ECONOMIC DISEASES IN SCOTLAND. By C. E. FOISTER, B.A., Ph.D.

(Read 17th October 1940.)

Toe-Rot Disease of Tomato was recorded in Scotland in 1936, although it was first discovered in 1934 by Mrs. Alcock. No thorough description of the causal fungus and its pathology has been published, although Howells (2) described the symptoms and gave suggestions for its control. It is hoped to publish a full account of this disease at a more propitious time, but herewith is given a technical diagnosis of the causal fungus which is named:—

Phytophthora verrucosa Alcock and Foister, spec. nov.

Mycelium ramosum, in juventate non septatum tandem leviter septatum atque vacuum. Sporangia 41·5 × 29·5 μ (31–56 × 24–36 μ), inversi-pyriformia vel ovalia, acrogena vel pleurogena, papillis et pediculi deficientibus, apice late rotundata et leviter incrassata; germinatio per zoosporas. Sporangiophora per zoosporangia evacuata penetrantia et zoosporangia nova gignentia. Oogonia acrogena vel rarius intercalaria, sphaerica, 37 μ (23–47 μ), crasse tunicata (4·7 μ), membrana extera verrucosa vel rarius leve. Antheridia acrogena vel rarius intercalaria, paragyna, 16 × 13 μ (11–22 × 10–17 μ), vel amphigyna, 17 × 5 μ (9–22 × 8–20 μ). Oosporae sphaericae, maturitate melleoflava, 24 μ (17–31 μ), hyalinae, membrana leve 3 μ crassa. Hab. in radicibus *Lycopersici esculenti* et *Meconopsis* spp. in ins. Brittannicis.

[Mycelium branched, non-septate when young, slightly septate and empty when old. Sporangia 41·5 × 29·5 μ (31–56 × 24–36 μ), inversely pyriform or oval, terminal or lateral, on undifferentiated sporangiophores 15 to 250 μ long, non-papillate with broadly rounded, slightly thickened, hyaline apex, no pedicel, germinating by zoospores, mouth of discharge broad. Further sporangia produced commonly within and rarely beyond an empty one by renewed sporangiophore growth. Sexual organs developed in or more commonly on surface of cortical tissues. Oogonia terminal, rarely lateral, spherical, 37 μ (23–47 μ), usually with very thick wall 4·7 μ (1·7–7·7 μ), internally unevenly thickened, collapsing when thin-walled, outer wall predominatingly verrucose, sometimes smooth. Antheridia paragynous 16 × 13 μ (11–22 × 10–17 μ) or amphigynous 17 × 15 μ (9–22 × 8–20 μ), commonly terminal, rarely lateral. Oospores spherical, light golden brown with age, usually lying free within oogonium, 24 μ (17–31 μ), hyaline with smooth 3 μ-thick wall. Parasitic on roots of cultivated Tomato and *Meconopsis* spp.]

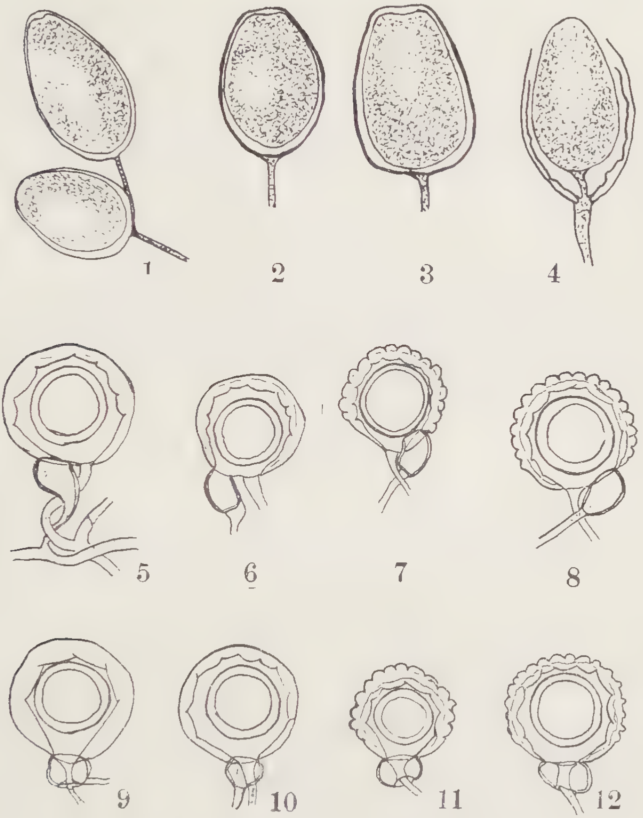
Gangrene Disease of Potato was recorded and described in some detail in 1936 (1). Pending a fuller account of this disease the following diagnosis is given of the causal fungus which is named:—

Phoma foveata Foister, spec. nov.

Pycnidia numerosa nunc singularia nunc gregaria, subcoriacea, ex toto immersa vel in parte erumpentia, vulgo globosa, rostro et ostiolo deficientibus, 177 × 187 μ (105–309 × 110–418 μ), rarius multilocularia, muro crassissimo cincta, pseudo-subiculatim frequenter evoluta. Pycnosporae oblongae vel ovoideae, hyalinae, continuae, rarius 1–2 septatae, 5·7 × 1·7 μ (3·2–7·7 × 1·1–2·1 μ). Hab. in tuberibus *Solani tuberosi*, primo depressiones circulares tandem putredinem internam producens. In ins. Britannicis crescit.

[Pycnidia numerous, isolated or gregarious, sub-coriaceous, totally immersed to partially erumpent, irregularly shaped but mostly globose, beak and ostiole absent or indistinct, wall very solid and dark brown with a lining of thin hyaline cells, commonly situated in pseudo-subicular sheets, often superimposed, 177 × 187 μ (105–309 × 110–418 μ), rarely compound. Pycnospores oblong or ovoid, hyaline, continuous, very rarely 2–3 celled, 5·7 × 1·7 μ (3·2–7·7 × 1·1–2·1 μ), borne singly on simple very short sporophores, yellow-cream in mass, extruded from pycnidia as globules. Chlamydospores, dark brown, in chains. Hab. in tubers of cult. potato causing circular depressions proceeding to internal rot. Great Britain and N. Ireland.]

In culture *P. foveata* is distinct from those of *P. eupyrena*

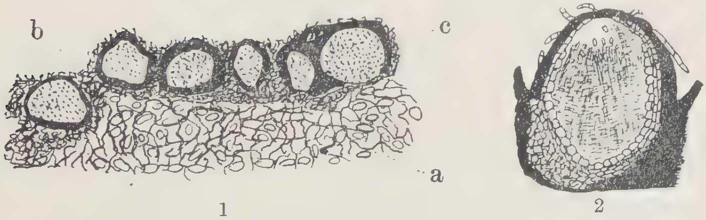


Phytophthora verrucosa Alcock and Foister.

Figs. 1–4.—Sporangia: Fig. 4, Sporangium proliferating twice.

Figs. 5–8.—Paragynous antheridia.

Figs. 9–12.—Amphigynous antheridia.



Phoma foveata Foister.

Fig. 1.—Pycnidia near surface of potato tuber: a, mycelium among starch grains; b, undifferentiated close-woven mycelium; c, pycnidia.

Fig. 2.—Single pycnidium; thick outer wall and thin-celled inner layer.

Sacc., *P. solanicola* Pr. et Del., and *Phomopsis tuberivora* Güss. et Foster, species described as parasitic on potatoes.

The writer wishes to express his gratitude to Professor Sir W. Wright Smith for his assistance in the Latin diagnoses and to Dr. M. J. F. Gregor for some of the measurements of the two above fungi.

REFERENCES.

(1) ALCOCK, N. L., and FOISTER, C. E. (1936): A Fungous Disease of Stored Potatoes. Scot. Journ. Agric., xix, 252–257.

(2) HOWELLS, D. V. (1936): Phytophthora Disease of Tomato (Toe Rot). Scot. Journ. Agric., xix, 47–50.

TRANSACTIONS

OF THE

BOTANICAL SOCIETY OF EDINBURGH

SESSION CV

PRESIDENTIAL ADDRESS—FLORAL MORPHOLOGY AND ITS BEARING ON THE CLASSIFICATION OF ANGIOSPERMS.

By Professor J. R. MATTHEWS.

(Read 27th February 1941.)

When you did me the honour last year of electing me President of your Society, Europe was already at war and it seemed doubtful whether the activities of the Society could be carried on. Fortunately, we have been able to continue our meetings, if in somewhat attenuated form, and we do well, I think, in trying to maintain our long traditions and in endeavouring to give encouragement for the future. When I was reminded by your Secretary that I would be expected to give a Presidential Address, I reflected, in view of the Society's long association with the Edinburgh School of Botany, that some remarks on Floral Morphology and Classification of Angiosperms might not be inappropriate, although it is manifest that I can touch only the fringe of so great a subject.

At the time when the foundations of our Society were being laid, over a hundred years ago, the conception of the flower most widely accepted was based on Goethe's theory of metamorphosis, and its application to the reproductive shoot in Angiosperms led to the idea of the flower as a branch or shoot whose leaves were progressively modified in the direction of bract, sepal, petal, stamen and carpel, the carpel being the culmination of the series. This view is made clear from a text-book of the period. In his "Class Book of Botany," Hutton Balfour, for example, speaks of the flower as embracing "all the organs, however inconspicuous, which are concerned with the production of seed. These organs, or parts of the flower, must all be considered as modifications of leaves. In their structure and arrangement they are similar to the foliar organs, and they follow the same laws of development." The description continues: "The different organs are verticillate leaves, produced at nodes which are placed close to each other, without the intervention of marked internodes." In other words, the definition here draws attention to the important feature that the flower axis is of limited growth.

This classical interpretation of the fundamental nature of the flower has been the subject of much discussion and still finds a prominent place in botanical literature. It has long provided an impetus to research into the real nature of the flower axis and its appendages, and the elaborate works of Payer (1857), Eichler (1875), and Van Tieghem (1875) may be cited as outstanding contributions which appeared during the second half of the nineteenth century. It is evident that the general idea of homology was clearly in the minds of pre-Darwinian writers, and although its evolutionary significance did not enter into systematic works of the period, there seems little doubt that the importance which A. P. de Candolle attached to the comparative morphology of the flower contributed to the advance he achieved upon most earlier systems in his classification of Angiosperms published in 1813. To a considerable extent his system was founded upon a morphological basis, and as extended by his son, in 1844, it became the general scheme which was elaborated by Bentham and Hooker in the "Genera Plantarum" (1862–1883).

While the foliar nature of most of the floral organs seemed fairly obvious in terms of the Goethean theory, difficulties soon arose over such structures as the ovule, its funicle and integuments, and the placenta. With regard to these parts, comparisons were drawn which now appear strange and fantastic, "to such straits had the domination of a so-called law—the theory of metamorphosis—driven its votaries." It was not until Goebel in 1881 pronounced the sporangium an organ *sui generis*, whatever its position, that a new approach was made towards an understanding of the ovule. Under the influence of Hofmeister's great discoveries it gradually became apparent that stamen and carpel were concerned with the production of sporangia, and in the course of time the term sporophyll was applied to them. The general morphology of the flower then seemed to fall into line with what was known about the reproductive system in certain lower groups, and it is only recently that such an apparently simple explanation has been challenged. Meanwhile the search for homologues continued, directed largely to the nature of the ovule. It is beyond the scope of this address to enter into those refinements of morphological inquiry which improvements in cytological technique have made possible, but reference may be made to a few events which left their impression at the time both on taxonomy and phylogeny. Strasburger, in 1884, first made clear the details concerned in fertilisation, and in 1898 Nawaschin announced the discovery of what has come to be spoken of as double fertilisation. Subsequent study has shown the phenomenon to be so general among Angiosperms as to furnish an argument in favour of the monophyletic origin of the group. In 1891 Treub reported the occurrence of chalazogamic fertilisation in *Casuarina*, a feature which was regarded as so essentially different from porogamy that a classification of Angiosperms into Chalazogamae and Porogamae was proposed. The scheme was soon abandoned, however, when later investigations demonstrated the absence of any complete uniformity in the mode of approach of the pollen tube to the embryo-sac. While much developmental and cytological study of the Angiosperms continues, often with special reference to their genetic system, the problem of floral morphology has been approached within recent years from several new aspects, and some, if not most, of the old concepts are being submitted to re-examination.

Reference should be made, however, to that period about the beginning of the present century when speculations concerning phylogeny coincided with the search for a "primitive type" among Angiosperms. So long as morphological ideas were based upon the study of form and development of the individual flowering plant, it was natural to regard the foliage leaf as preceding the sporophyll not only ontogenetically but phylogenetically. The sporophyll was regarded as a vegetative leaf which had become fertile. But a wide comparative study of the development and morphology of archegoniate plants led Bower to put forward an opposite view, that foliage leaves are often the equivalent of sporophylls which have become sterile. On this view metamorphosis, if it played any part at all, proceeded in a descending rather than ascending order: the question thus presented was fully discussed in "The Origin of a Land Flora" (1908). With the recognition of stamen and carpel as sporophylls, it became tempting to compare the flower with the reproductive shoots found in certain Gymnosperms, more especially the Cycadales. The question arose as to whether the idea of the strobilus could be applied to the angiospermic reproductive shoot. Certain types belonging to families of the Ranales seemed to provide favourable material for comparison with the strobilus in lower groups. In Magnoliaceae and many Ranunculaceae the flower appeared to be relatively unspecialised, if not actually primitive, and it was on the comparison of existing forms that Arber and Parkin (1907) based their well-known theory of the primitive flower. By a fortunate circumstance they were able to compare their reconstruction of a hypothetical pro-angiospermic type with the strobilus of the American Bennettitales then being described by Wieland, which revealed the existence during the Mesozoic of a reproductive shoot which seemed to harmonise in its general features with many of the characters visualised for a primitive Angiosperm. One of the chief difficulties of the theory lies in the comparison of the female reproductive part of the Bennettitales with that of Angiosperms, and Chamberlain (1934) in his recent volume on Gymnosperms makes the emphatic statement: "That the Bennettitales may have given rise to any of the Angiosperms we regard as not only improbable but impossible." He believes the resemblance of the bisporangiate fructification of the former to the Magnolian type to be superficial, and concludes: "The Bennettitales were the last of their line; they left no progeny." Yet the acceptance of Arber and Parkin's view as a working hypothesis gave promise, under the influence of the Darwinian theory, of a phylogenetic starting-point upon which a natural classification of Angiosperms might be built. The theory did not, however, meet with general acceptance among systematic botanists, and in one of the most useful modern textbooks—Rendle's "Classification of Flowering Plants"—the system adopted is essentially that of Engler and Prantl. On the other hand, in the more recent proposals put forward by Hutchinson in "The Families of Flowering Plants," the Magnoliales and Ranales are, in fact, both regarded as basic groups. It may be recalled also that, ten years before the publication of Arber and Parkin's theory, Bessey (1897) had, independently, and on a broad basis of comparison among existing Angiosperms, proposed a phylogenetic system in which Ranales were regarded as relatively primitive. Hallier (1905) made somewhat similar proposals. It is of greater historic interest, perhaps, that the arrangement of the main groups of families in the "Genera Plantarum," the general plan of which had been formulated before the publication of "The Origin of Species," seemed to support the theory advanced by Arber and Parkin. But Hooker had no preconceived ideas about the phylogeny of Angiosperms, and the sequence of families in the "Genera Plantarum" was never intended to be phylogenetic. In a letter dated 1907 to Newell Arber he wrote: "With regard to your queries respecting the primitive type of Angiospermous plants, that subject has never been far from my mind for upwards of half a century, during which period I have failed to grasp a feature in the Morphology, Physiology, or Geographical distribution of Angiosperms, that gave much color to whatever speculations I may have indulged in respecting it. I do not share Engler's views as expressed in his classification and writings. The classification is neither better nor worse in the abstract than De Candolle's (so-called), and is far more troublesome to apply for practical purposes. I hold to Robert Brown's view of the orders being reticulately not lineally related. . . . Lastly with regard to the primitive Type of Angiosperms, I am disposed to think that, apart from Geological Evidence, the channels along which this is to be sought have not been explored, if found."

Apart from the search for a "primitive type," the Ranunculaceae and related families figured in frequent discussions regarding the origin of the perianth, and certain Ranalian forms such as *Trollius*, *Helleborus*, and *Eranthis* were quoted in favour of the view that both petals and sepals were derived from stamens. On the other hand, the flower structure in species of *Anemone* was quoted in support of the argument that the calyx had arisen from involucral bracts which are evidently foliar. Difficulties of interpretation may be resolved by ontogenetic and anatomical studies, and in the case of *Ranunculus parviflorus*, for example, Salisbury (1931) has found evidence of the foliar nature of the sepals, while Eames (1931) also concludes from evidence of vasculation that sepals, in nearly every case, have been derived from leaves and are not sterile sporophylls. Reference to primitive vascular plants suggests, however, that the leaf may have originated in more than one way, and a genetic distinction has been drawn between megaphylls and microphylls, the former being referable to cladode leaves, the latter to enations or outgrowths from the axis. A full discussion is given by Bower in "Primitive Land Plants" (1935) where the argument is developed after a detailed examination of archegoniate plants at large. If the angiosperm reproductive shoot can be brought within the scheme it would not be impossible to contemplate more than one kind of appendage arising from the flower axis. Such a view would depart from the traditional one, which makes all parts of the flower conform to one morphological category. The data are not available, however, for any final pronouncement, but since Angiosperms, so far as is known, have but a brief geological history it has been argued that the leaf, whatever its origin, was fully established and of diverse form before flowering plants came into existence. Some writers have maintained, therefore, that it is unnecessary to regard any of the perianth parts of a modern flower as having been derived from pre-existing sporophylls. The axis of the primitive flower may have been devoid of any but fertile appendages, and the primitive perianth may have originated later as foliar outgrowths of the axis below the sporophylls.

Such opinions found expression in the systems of classification developed by Warming, Wettstein, and Engler and Prantl. According to these authors the naked or monochlamydeous type of flower is primitive and the groups of families are arranged in a more or less ascending series chiefly according to increasing complexity of the perianth. One of the merits of the Englerian system was the abolition of the Monochlamydeae of Bentham and Hooker and the incorporation of this group among the Polypetalae to constitute a sub-class styled the Archichlamydeae, but it may be doubted whether the change made Engler's system as a whole any more phylogenetic. It may be noted in passing that the priority of position which the continental systems gave to the Monocotyledons renewed interest in the relationship between this group and the Dicotyledons. If the numerous researches arising therefrom did not finally solve the problem, they added greatly to our knowledge of the structure and development of Angiosperms as a whole. A review of literature concerning the evolution of Monocotyledons has been given by Bancroft (1914), and a detailed morphological study of the group was published by Arber in 1925, while their phylogeny has been discussed by Campbell (1930). The general consensus of opinion seemed to favour the view that Monocotyledons have been derived from a dicotyledonous ancestry, and in consequence attention became all the more concentrated on Dicotyledons in attempts to solve the origin of angiospermic plants in general.

While much of the research into angiosperm morphology has been pursued for its own sake, one can generally detect an expression of hopefulness that relationships or phyletic trends would be revealed. Nevertheless, the two main systems of classification at present in general use—Engler's, and Bentham and Hooker's—are almost diametrically opposed in respect of a phylogenetic starting-point. In the broad outline of Engler's scheme too much stress may have been laid on the characters of the perianth and too little on those of the androecium and gynoecium. While a progressive elaboration of the perianth from a simple ancestral type may have occurred, it is more difficult to visualise the derivation of an apocarpous condition of the gynoecium from the syncarpous state which is prevalent among those families placed at the beginning of the Englerian system. On the other hand, reduction and fusion, or what is better described as tubular development, seem to have been general processes in the evolution of the flower, and if this be so, the occurrence of relatively few stamens combined with a syncarpous gynoecium, as seen in many of the early Archichlamydeae, scarcely suggests primitiveness.

Morphological comparisons should not be employed, however, to the exclusion of biological considerations. In primitive land plants the spore output, for example, is usually large, and for the Filicales it has been shown conclusively that relatively primitive types have a higher spore output per sporangium than those relatively advanced. With the establishment of heterospory, a large production of spores remains a general feature of the microsporangium, and the progressive tendency towards limitation of spore production seen in the Ferns may possibly have been repeated in the stamen of Angiosperms. We have little information, however, regarding pollen output among flowering plants although there is obviously much variation. If any significance can be attached to the suggestion, it would point to the polyandrous flower with large anthers as being relatively primitive for this feature. Since stamens normally take their origin from the floral axis prior to the carpels, and have in consequence greater freedom of expansion, they might be expected to retain some of their primitive characters independent of carpel behaviour and output of ovules. Evolutionary progressions seldom affect different organs at the same rate. In considering the structure of the primitive flower and the classification of flowering plants it seems not unreasonable, therefore, that as much emphasis should be placed on the characters of the androecium as the gynoecium. This has been recognised in the rearrangement of the primary groups of Dicotyledons recently proposed by Burtt Davy (1937), who places all polystemonous groups before those which exhibit oligostemony, a re-grouping supported by evidence derived from an examination of the wood anatomy of many of the genera concerned. The polyadelphous flower also deserves consideration. I well remember Bayley Balfour in his lectures on flowering plants putting forward the suggestion that if any primitive characters remain among modern angiospermic microsporophylls they should be looked for among those families having polyadelphous flowers, *e.g.* Guttiferae, Hypericaceae, Dilleniaceae, Theaceae, and Cistaceae. Where the development is known, it appears that the staminal members in each "bundle" of stamens are formed in basipetal succession, and it has been customary to regard such stamen bundles as being due to splitting of an original small number. It seems possible, however, to look upon the stamen phalange as a branch system, and to picture the primitive angiospermic flower as possessing microsporophylls which showed distal branching. From such a condition of the androecium the modern flower having numerous stamens could be derived. That the stamen has indeed arisen from a complex branch system is suggested by the recent investigations of Wilson (1937). An examination of the vascular system of the androecium in Dilleniaceae, Ochnaceae, Guttiferae, Bombacaceae, Malvaceae and other families has led this author to suggest that "an explanation of the stamen fascicle trace may be obtained by postulating as the ancestor of the stamen a primitive dichotomous branch system similar to those known to have existed in ancient and now extinct plants. Reduction of such a branch system has probably proceeded in many directions. Reduction of the main limb of such a branched structure, accompanied by the suppression of certain portions of the branches, would account for the common occurrence of numerous stamens in various forms. Reduction of the main limb of such a system, again, together with lateral fusions in the branches, would account for the stamen fascicle. . . . The prevailing type of Angiosperm stamen, with its complement of four sporangia, is on this view regarded as the result of the further shortening of the termini of such a branch system, thus bringing into close conjunction two bisporangiate synangia. If the leaf is the end result of the evolution of a major branch system, a logical conclusion from paleobotanical studies, then the modern stamen is not homologous with the entire leaf, as stated under the classical theory of the nature of the sporophylls of the flower; it is rather homologous with only a part of the leaf, and the term sporophyll may no longer be applied."

When we turn to consider the morphological nature of the carpel we find that here, also, recent views are not always in agreement with the classic interpretation of this organ as an infolded leaf bearing ovules along its fused margins. In the apparently simple case of the follicle or the legume, the foliar nature of the carpel seemed evident enough to the early morphologists, and, as pointed out by Arber (1937), it was a bold measure to bring the great variety of angiospermic gynoecia within a unified scheme based on the simple idea of the carpel as a foliar body. For purposes of classification the idea of uniformity has proved remarkably useful, since systematists have been able to assemble in orderly fashion a multitude of forms largely on a basis of comparison of gynoecial structure. Even the opponents of the traditional view of the carpel recognise its convenience for purposes of description.

But the old idea has been challenged, and among recent writers Miss Saunders has advanced the theory of carpel polymorphism according to which carpellary structures are not of a uniform type, but comprise two main forms (*a*) the valve, and (*b*) the consolidated type, together with intermediate connecting forms. Miss Saunders has applied her theory to a wide range of families and has made her general conclusions available in her recently published "Floral Morphology" (1937, 1939). The new viewpoint has aroused much controversy, and a full review with references to literature on the subject has been given by Bancroft (1935). Reference will only be made here to the criticisms of Eames (1931), who concludes from anatomical evidence that the carpel, although the most complex of floral organs, is in general a foliar structure, usually with three traces, and that it has probably been derived from a three-lobed palmate leaf. This idea has been carried further by Hunt (1937), who believes that the carpel may be traced ultimately to a dichotomous branch system, the dichotomies being most frequently found in the stigmas supplied by the dorsal bundle. According to Hunt, an unspecialised palmately three-lobed appendage of the flower axis represented an intermediate stage in the derivation of the carpel. On this view, therefore, the carpel, like the stamen, may be referred to an ancestral type characterised by dichotomous branching.

Whatever the origin and ultimate nature of the closed carpel of Angiosperms, its possession of a stigma provides a character whose biological significance deserves more attention than it has received. Thomas (1934) has discussed the possible origin and evolution of the stigma and drawn attention to some of the physiological problems involved, while Robertson (1904) has considered the possible evolutionary significance of anemophily and entomophily. Wernham (1913) has also stressed the importance of biological features in his account of floral evolution in the Gamopetalae. At whatever stage in the long history of seed-plants the enclosure of ovules took place, the inevitable consequence was the cessation of "gymnospermous" pollination and a new problem arose in connection with the mechanism of reproduction. In primitive seed-plants, if they are gymnospermic, the pollen grain comes to rest on or near the nucellus, and a relatively short pollen tube suffices for the transference of the male reproductive cells. When the state of angiospermy is attained, the pollen grain does not arrive on the ovule but on a receptive surface, the stigma of the body enclosing the ovule. It is evident that physiological problems would arise in consequence of the new position in which the pollen grain finds itself; for example, the greater growth in length of the tube, the provision of conducting or "transmission" tissue for the tube, and the avoidance of the handicap imposed by air spaces within a closed ovary. It is here suggested that the power of growth of the pollen tube when angiospermy first became established was probably limited, and that a "receptive surface" for pollen at no great distance from the ovule (or ovules) would be a biological advantage. As is well known, the distance to be traversed by the pollen tube in modern Angiosperms varies considerably according to whether the stigmas are sessile or borne on styles of varying length. It is true that the long style is commonly related to tubular development of some part of the flower as in most Gamopetalae and many Monocotyledons, but among families which are polypetalous or apetalous the possession of sessile or only slightly elevated stigmas may not be without significance.

Time permits of reference to only one other feature in the morphology of the flower. In all attempts to formulate a "natural" classification of Angiosperms it has generally been assumed that hypogyny, perigyny, and epigyny represent an advancing series in floral evolution and that epigyny is a derivative state. The transition from one condition to the other in certain groups is often so gradual as to become very suggestive, and, to quote a particular case, the disposition of the vascular supply in the flowers of *Pyrola*, *Gaylussacia*, and *Vaccinium* is regarded by Eames (1931) as evidence for the view that epigyny has, in fact, been derived from hypogyny in consequence of the adnation of the outer floral whorls to the carpels. That epigyny is a recurrent feature along numerous lines of descent within the Angiosperms is clear from its occurrence in isolated families in various cycles of affinity, *e.g.* Nymphaeaceae, Saxifragaceae, Onagraceae, and Vacciniaceae, and in this connection it is of interest that Hutchinson ("The Families of Flowering Plants") gives less prominence than has been usual to the systematic value of epigyny in his rearrangement of the families Liliaceae and Amaryllidaceae.

The difficulty of interpreting the inferior ovary in terms of the old carpellary view of the gynoecium has recently been brought into special prominence by the work of McLean Thompson (1931, 1933, 1934, 1937), who believes that the fundamental nature of the Angiosperm flower is not likely to receive further elucidation by a study of mature structures alone. He has elaborated the ontogenetic approach to the problem, and contends that the modern flower should be its own interpreter by following the details of its ontogeny species by species. The theory of the strobilus may still be accepted, and reduced to its simplest terms "the basis of a flower is neither more or less than a sporogenous axis," which is potentially heterosporous. The basal part of the axis is sterile, and bracts, bracteoles, and sepals are products of the sterile base and are of the nature of transitional foliage. The lower portion of the sporogenous region is potentially microsporangial, and the emergences which arise mature as stamens, though there may be diversion by sterilisation to petals or staminodes. The final positions of these organs "are determined according as apical growth of the floral axis is maintained, or is replaced by toral growth." When toral growth prevails, the maturing axis is cup-shaped and the condition of the flower with an inferior ovary is initiated. Emergences now formed from the sporogenous tissue on the rim of the cup may be diverted from spore-bearing, and they mature as stigmatic organs while the remaining axial surface lining the cup is potentially megasporangial. The emergences which now appear are placentae, from whose megasporangial surface nucellar outgrowths arise, ultimately maturing as ovules. In the ontogeny of the flower with inferior ovary there is no question of ovuliferous carpels —the flower is "acarpous"—and there is no question of derivation from a type with superior ovary. According to Thompson, "the only essential difference between the flower with inferior ovary and the flower with superior ovary lies in the course of development of the spore-bearing axis." The flower with superior ovary is not considered primitive nor the flower with inferior ovary considered advanced. Neither is derived from the other: they express distinct states of flowering and "they may exist simultaneously in a single accepted affinity." The last statement is indisputable, and to any taxonomist interested in phylogeny it is difficult to believe that no genetic connection exists between hypogyny and epigyny where the two conditions are found associated among genera which are acknowledged to be closely related. The limitations imposed upon growth in the axis of the modern flower, which is one of its most characteristic features, may have led to varying evolutionary attempts in the nature of "short cuts." The failure to develop evident carpels in the inferior ovary may be one. But the evidence of floral ontogeny advanced by Thompson certainly commands attention, more especially in regard to the nature of the stamen and ovule, and if his theory of "acarpous" flowering is accepted, the criteria employed in the classification of Angiosperms will have to be re-examined.

That we are at the beginning of a new phase in the study of Angiosperm morphology can scarcely be doubted, and there is clear evidence also of a re-awakening of interest in the problems of taxonomy and phylogeny. No taxonomist at the present time would suggest that any existing scheme of classification is phylogenetically complete: all systems are rather in the nature of tentative proposals, and so long as palaeobotany offers no conclusive evidence regarding the origin of Angiosperms, advance in their taxonomic treatment and fuller understanding of their inter-relationships may best be achieved by more intensive study of the living plants themselves.

REFERENCES.

ARBER, A. (1925): Monocotyledons: a Morphological Study. Cambridge.

—— (1937): The Interpretation of the Flower: A Study of Some Aspects of Morphological Thought. Biol. Rev., xii, 157–184.

ARBER, E. A. N., and PARKIN, J. (1907): On the Origin of Angiosperms. Journ. Linn. Soc. (Bot.), xxxviii, 29–80.

BANCROFT, H. (1914): A Review of Literature concerning the Evolution of Monocotyledons. New Phytologist Reprint, No. 9.

—— (1935): A Review of Researches concerning Floral Morphology. Bot. Rev., i, 77–99.

Bessey, C. E. (1897): Phylogeny and Taxonomy of the Angiosperms. Bot. Gaz., xxiv, 145–178.

Burtt Davy, J. (1937): On the Primary Groups of Dicotyledons. Ann. Bot., N.S., i, 429–438.

Campbell, D. H. (1930): The Phylogeny of Monocotyledons. Ann. Bot., xliv, 311–331.

Eames, A. J. (1931): The Vascular Anatomy of the Flower, with Refutation of the Theory of Carpel Polymorphism. Amer. Journ. Bot., xviii, 147–188.

Eichler, A. W. (1875): Blüthendiagramme. Leipzig.

Hallier, H. (1905): Provisional Scheme of the Natural (Phylogenetic) System of Flowering Plants. New Phytol., iv, 151–162.

Hunt, K. W. (1937): A Study of the Style and Stigma, with Reference to the Nature of the Carpel. Amer. Journ. Bot., xxiv, 288–295.

Payer, J. B. (1857): Traité d'organogenie comparée de la fleur. Paris.

Robertson, C. (1904): The Structure of the Flower and the Mode of Pollination of the Primitive Angiosperms. Bot. Gaz., xxxvii, 294–298.

Salisbury, E. J. (1931): On the Morphology and Ecology of *Ranunculus parviflorus* L. Ann. Bot., xlv, 539–578.

Thomas, H. H. (1931): The Early Evolution of the Angiosperms. Ann. Bot., xlv, 647–672.

—— (1934): The Nature and Origin of the Stigma. New Phytol., xxxiii, 173–198.

Thompson, J. McL. (1931): Studies in Advancing Sterility. Part V. The Theory of the Leguminous Strobilus. Publ. Hartley Bot. Lab. No. 7.

—— (1933): Studies in Advancing Sterility. Part VI. The Theory of Scitaminean Flowering. Publ. Hartley Bot. Lab. No. 11.

—— (1934): Studies in Advancing Sterility. Part VII. The State of Flowering known as Angiospermy. Publ. Hartley Bot. Lab. No. 12.

—— (1937): On the Place of Ontogeny in Floral Enquiry. Publ. Hartley Bot. Lab. No. 17.

Van Tieghem, P. (1875): Recherches sur la structure du pistil et sur l'anatomie comparée de la fleur. Mem. Acad. Sci. Inst. Imp. France, xxi, 1–262.

Wernham, H. F. (1913): Floral Evolution with Particular Reference to the Sympetalous Dicotyledons. New Phytologist Reprint, No. 5.

Wilson, C. L. (1937): The Phylogeny of the Stamen. Amer. Journ. Bot., xxiv, 686–699.

THE MARINE ALGAL ASSOCIATIONS OF ST. ANDREWS DISTRICT. PART I: THE DOMINANT ASSOCIATIONS OF THE SPRAY AND LITTORAL REGIONS.

By MARY D. DUNN, Ph.D.

(Read 22nd May 1941.)

Early work in algology in Fife was mostly systematic and confined to the Firth of Forth. Traill (9) made collections of marine algae at various places along the south coast of the county, notably at Elie, and published several lists of his collections, as well as a Monograph of the Algae of the Firth of Forth. In a letter written by him in 1887, he stated that he had also collected on the coast from St. Andrews to the Buddo Rock (three miles east of the town), but that he had never published the results. More recently, about 1930–31, Terras made a collection of algae at Crail, and his list was published, along with a short list of algae found at St. Andrews, by Lowe (6). The present writer (4) has extended this work and listed the algae found on seven miles of coast in the neighbourhood of St. Andrews.

The first ecological paper to be published on the marine algae of the British coasts was by Rattray (8), who worked mostly on the south side of the Firth of Forth. Following Kjellmann, the first to study algal communities, he arranged the flora in "areas" according to the level on the shore at which it occurs, giving the dominant species and the associated plants. Baker (1), working in the Isle of Wight and in Norfolk, treated several species of Phaeophyceae from an ecological point of view, but Cotton (3) was the next to publish a paper in this country dealing with all the algal communities of a district—Clare Island, in the south-west of Ireland. It was not until 1929 that this work was restarted, when members of Queen's University, Belfast, began a study of the coast of N. Ireland. The whole of that coast-line has now been surveyed by them, and the results published in a series of papers in "The Irish Naturalists' Journal" between 1929 and 1937. Others have followed with ecological work at various places round the British coasts.

In the present survey of the coast round St. Andrews Bay from St. Andrews to Boarhills (five miles), certain factors have been found to be operative in the distribution of the marine vegetation. These factors are:

1. *Desiccation.*—The most important factor to be considered is the ebb and flow of the tide, with consequent risk of desiccation to the plants, which are thus left dry by the tide for several hours twice each day. Thus there is a distinct zonation, the plants in the higher zones being better adapted to withstand this desiccation than those growing lower down. This has been shown experimentally by Baker (1). Exposure to desiccation is found to be so harmful to some algae that they occur only in pools or in the sub-littoral zone.

2. *Substratum and Wave Action.*—The texture of the rocks, the presence of barnacles, steep inclination, and wave action all prevent the spores of algae from settling and obtaining a foothold. The presence of sand and mud deposited on the rocks has also a great effect on the components of any association.

3. *Light and Aspect.*—Greater or less shade also affects the flora, many algae being adversely affected by too bright sunlight and therefore growing best on the shaded side of the rocks and in the crevices where the shade is most intense. On the east coast the position of the cliffs may cause a shade to fall on the littoral region to a greater or less extent, varying with the closeness of the cliff. In the eastern part of the surveyed area the cliff is more remote and does not cast much shade on the rocky shore, but nearer the town the waves wash the foot of the cliffs at high water and the uppermost part of the littoral region is shaded for the greater part of the day. This causes some variation in the distribution of the flora.

4. *Salinity.*—Reduction of salinity by the presence of freshwater streams effects a considerable change on the flora.

A great part of the shore in the surveyed area is composed of rock much broken up. Long, high ridges run at varying angles causing great differences of light and shade, as well as of exposure to direct wave action. This irregular formation, considered in conjunction with the factors 2 and 3 mentioned above, cause great irregularity of distribution among the algae. But in spite of this the most marked feature is their zonation.

The shore may be divided into (I) the Spray Region, which is only reached by very high spring tides and often just splashed by spray; (II) the Littoral Region, from high-water mark to low-water mark (spring tides); (III) the Sub-littoral Region, below low-water mark of spring tides.

It is proposed in this paper to describe the flora of the spray region and the dominant Phaeophycean associations of the littoral and sub-littoral regions. The undergrowth to the larger plants, consisting of brown, red, and green algae, and where these are grouped into definite associations, are merely mentioned here, their description being left to a further publication.

I. The Spray Region.

This is the zone of the maritime lichens and bryophytes, including the following species:—

1. *Frullania Tamarisci*
   Parmelia saxatilis
   Buellia canescens
   Opegrapha calcarea
2. *Ramalina scopulorum*
   Lecanora parella
   Grimmia maritima
   Physcia aquila
   Lecanora atra
3. *Physcia parietina*
   Placodium murorum
   Lichina confinis
   Verrucaria maura

The list is in descending order to high-water mark, the third group extending into the littoral region amongst *Pelvetia*. The lichens in this third or lowest group are therefore submerged by spring tides. Many of the rocks in and above the *Pelvetia* zone are covered with the black closely encrusting *Verrucaria maura*, amongst which are clumps of the tufted *Lichina confinis*. Slightly higher in the zonation come the two yellow forms, *Physcia parietina* and *Placodium murorum*, covering the rocks with bright yellow patches. The middle zone of lichens, accompanied by the moss, *Grimmia maritima*, are not submerged but are wet by the spray from spring tides. The brown *Physcia aquila* and the grey and whitish Lecanoras encrust the rocks amongst the fruticose *Ramalina*. There is a good deal of overlapping between this band and the lower one. Highest of all, the encrusting forms, *Buellia* and *Opegrapha*, appear on steep rocks, while on flatter rocks, where some soil has collected, the dominant lichen is *Parmelia saxatilis*, along with the liverwort *Frullania*. These are not even wet by spray except by an exceptionally high tide. All these marine and maritime lichens are best developed where the cliffs are remote; they do not develop to any extent where the cliffs cast a shade on this part of the shore.

An encrusting alga, *Hildenbrandia prototypus*, is associated with the marine lichens. Being more susceptible to desiccation than the lichens, it is confined to the more shaded side of the boulders, where the very thin thallus gives the rock a redder appearance. *Hildenbrandia* is not confined to this high level on the shore, but may be found all the way down to low water, in patches on the rocks amongst the Fucoids.

II. The Littoral Region.

This region lies between high- and low-water marks of ordinary spring tides. The dominant marine algae in the littoral region are Phaeophyceae, belonging to the orders Fucaceae and Laminariaceae. Amongst the Fucaceae the species common to all parts of the British coasts are found: *Pelvetia canaliculata*, *Fucus spiralis*, *Ascophyllum nodosum*, *Fucus vesiculosus*, *Fucus serratus*, *Himanthalia lorea*, as well as *Fucus ceranoides*, which is found where freshwater streams reduce the salinity. These species occur in zones in the above order from high-water to low-water mark, but all zones are not present at all parts of the shore, the factors determining their occurrence being mainly substratum and wave action.

a. *Pelvetia canaliculata* association. The Fucoid best adapted to withstand desiccation is *Pelvetia canaliculata*, a zone of which grows between high water of an ordinary tide and high water of a spring tide. The short, tufted plants may not even be wet by the spray at a neap tide and they become very dry and brittle, but quickly recover when again immersed by a spring tide. This zone occurs on the greater part of the coast-line in the surveyed area, but is absent where the highest part of the littoral region is exposed to extreme wave action. In the district round the town, where the sea washes against steep, densely shaded cliffs at high water, *Pelvetia* is present only on a few better lighted and less steep parts. It develops best on the low boulders, more or less protected by ridges acting as breakwaters. Where the shore is flat, this zone may be many yards wide. Thus steepness of slope, dense shade, and intense wave action are the factors against the growth of this species.

The sub-vegetation to *Pelvetia* consists of *Calothrix scopulorum*, *Verrucaria maura*, and *Catenella repens*.

Where *Pelvetia* is absent on an exposed shore its place is taken by an extension of the lichen zone, particularly of *Lichina confinis*; and on the shaded cliff by a dense growth of *Cladophora rupestris*. Other associations present in this zone of the littoral region are the general upper Chlorophyceae associations, *Porphyra* association, and the *Bangia-Urospora* association.

b. *Fucus spiralis* association. The form of *F. spiralis* common to this part of the coast is the variety *platycarpus* with a broad, flat thallus. A slight spirality is noticed in plants from the most exposed part of the shore, outside the shelter of the Bay. It comes immediately below the *Pelvetia* zone and forms a continuous band all along the shore at high water of neap tides, except for parts where there is sand or shingle instead of rock at this level. This is a species which can withstand wave action well, many of the high, irregular ridges all down the littoral region being topped by a growth of it. On the exposed coast the plants are more tufted, not forming such a dense covering as on the more sheltered rocks, but from no part of the rocky coast-line is it absent. In sheltered positions under protecting cliffs the plants are larger, and the thalli often show blister-like swellings.

Fucus ceranoides enters into the *Fucus spiralis* association at several places on the shore where small streams run down the braes and spread out on the shingle, influencing the flora on the rocks near high water by reducing the salinity. In such places the bushy plants of *F. ceranoides* mingle with *F. spiralis* on the rocks and also grow frequently in the pools, where they are associated with an abundant growth of Chlorophyceae, particularly *Enteromorpha intestinalis*, *Monostroma Grevillei*, and *Cladophora rupestris*. In spring and summer *F. ceranoides* is covered with epiphytic plants of which the principal are *Elachistea fucicola*, *Pylaiella littoralis*, and *Dictyosiphon hippuroides*.

c. *Fucus vesiculosus–Ascophyllum nodosum* association. The middle part of the littoral region, where there is sufficient shelter, is dominated by *F. vesiculosus*. On the gently sloping shore round the town, in the shelter of the Bay, it forms a zone many yards wide, covering the ridges and boulders. On the exposed shore where wave action is more intense this species leaves the ridges and high boulders and is found only on low, flat parts between boulders and on the sheltered sides of the ridges which act as breakwaters. In the more exposed sites it is the variety *evesiculosus* which is found, the form usually associated with turbulent conditions. With increasing shelter the number of air vesicles increases.

On the exposed shore in this zone the barnacle-covered boulders are often quite bare of algal growth, but many have dark patches of the marine lichen, *Lichina pygmaea*, which forms a dense, pure growth. On the steep sides of the ridges, many of which are more deeply shaded, there is less growth of *Fucus*, and low-growing algae, principally Rhodophyceae, form turfs over the ledges and extend into the crevices. The most general of these is the *Laurencia* association. As undergrowth to *F. vesiculosus* the commonest are *Cladophora rupestris*, *Gigartina stellata*, *Plumaria elegans*, *Callithamnion polyspermum*, and *Pylaiella littoralis*, dense growths of this last species being found as a covering to the rocks amongst the *Fucus* plants all the year round, the individual plants never more than 2 inches long.

The most frequent epiphytes associated with *F. vesiculosus* are *Elachistea fucicola*, *Ectocarpus tomentosus* (in spring and summer), *Polysiphonia fastigiata* (in the absence of *Ascophyllum*, its usual host), *Pylaiella littoralis* (in early summer), large plants up to 20 inches.

Ascophyllum nodosum enters into this association on the most sheltered parts of the shore only. It is the first of the Fucoid species to be affected by wave action, becoming confined to small areas which are in the shelter of high rocks, and then disappearing from the shore entirely with exposed conditions. It is found in the upper part of this zone, at some places being just below or even mingling with *F. spiralis*, at others, where more sheltered conditions prevail, extending farther down amongst the *F. vesiculosus*, but nowhere reaching the lower limits for that species. The undergrowth is the same as that for *F. vesiculosus*; the usual epiphyte is *Polysiphonia fastigiata*, while *Elachistea fucicola* and *Pylaiella littoralis* are also found on it.

d. *Fucus serratus–Himanthalia lorea* association. *Fucus serratus* is abundant at most parts of the coast-line at low water of neap tides. It covers low-lying or gently sloping rocks and boulders with a dense growth. The plants are large, having a longer period of immersion during each day, with less interruption to the process of assimilation than occurs with the species in the zones nearer high water. *Himanthalia lorea*, which is associated with *F. serratus* at most parts of the shoreline in the lowest part of its range, is more limited in its distribution. The presence of sand or silt deposited on the rock surface adversely affects *Himanthalia* to a greater extent than *F. serratus*. Thus, near the mouths of streams and big stretches of sand, *Himanthalia* is less frequent and may disappear from the association altogether. On the other hand, *Himanthalia* flourishes better in the presence of surf than *F. serratus*, so that an interchange of dominance is to be noted. On the quieter parts of this zone *F. serratus* is most abundant, while *Himanthalia* becomes dominant at places exposed to greater wave action with the breaking of surf over the rocks.

There is a greater variety of other associations in this zone, associations mainly composed of Rhodophyceae alternating with the Fucoids. In summer there is a big development of the green algae at this level, forming a lower Chlorophycean association. *Gigartina stellata*, which forms an association at a slightly lower level, extends into this zone as an undergrowth, along with *Chondrus crispus*, *Laurencia pinnatifida*, *Sphacelaria radicans*, and *Cladophora rupestris*. Added to these in summer are *Ceramium rubrum* and *Dumontia incrassata*. Besides *Elachistea fucicola*, the epiphytes growing on *F. serratus* are *Ectocarpus tomentosus*, *Pylaiella littoralis*, *Porphyra leucosticta*, *Ceramium rubrum*, and *Rhodymenia palmata*. Epiphytes associated with *Himanthalia* are *Elachistea scutulata* and *Ectocarpus velutinus*, both of which form a velvety covering over the thalli in summer.

e. *Laminaria digitata–L. hieroglyphica* association. On the lowest part of the littoral region, exposed only by spring tides, the dominant plants are these two species of *Laminaria*, which form a dense growth covering boulders and the bases of the ridges, as well as inhabiting the deeper pools. All round the coast there is a luxuriant growth of these large plants which on a gently sloping shore may form a zone many yards wide. These plants grow far up the shore, but are never exposed to desiccation for long periods because of the formation of the coast in long ridges of rock with low "lakes" between which fill up quickly at the turn of the tide. At most parts of the shore these two species are co-dominant, but occasionally a greater luxuriance of *L. hieroglyphica* is noticable. This occurs in more sheltered situations when a high ridge of rock running parallel to the shore forms a breakwater. Here specimens of *L. hieroglyphica* with blades 6–7 feet long are commonly found.

The annual regrowth of the lamina is not noticeable in *L. digitata*, but is very distinct in *L. hieroglyphica*. The long, narrow blade of this species becomes very tattered during autumn and winter. The blades become shorter, as well as losing their distinctive wavy margins. New growth begins in January and is completed by early summer. The old blades are not cast off, but are gradually worn away.

The dense growth of this association covers a rich undergrowth, including *Gigartina stellata*, *Ceramium rubrum*, *Polysiphonia nigrescens*, *Cystoclonium purpureum*, *Chondrus crispus*, *Dilsea edulis*, *Polyides rotundus*, *Ahnfeltia plicata*, and *Ulva lactuca* var. *latissima*.

Epiphytes are not common on the smooth stipes of these species, but several are found on the lamina during summer including *Ectocarpus fasciculatus*, *E. Hincksiae*, and *E. confervoides*.

III. The Sub-littoral Region.

f. *Laminaria Cloustoni* association. The upper part of the sub-littoral region is characterised by a dense growth of *L. Cloustoni*, associated with *L. saccharina* and *Alaria esculenta*, both much less abundant and widespread than *L. Cloustoni*. This dominant plant forms a wide zone all round the coast, interrupted only at places where the substratum is sand instead of rock. The plants are large and luxuriant, with long stipes, and are never fully exposed, only the tops of the stipes and laminas appearing above the sea at low tide. This is a plant which grows best on rough, rocky coasts exposed to considerable wave action. The conditions round St. Andrews suit it well, the shelving rocks just below low water being covered with a wide zone of the plant. *L. saccharina* is associated with it in small quantity, but, as it cannot endure any exposure to the air, is never seen until it is cast ashore. *Alaria esculenta* is very restricted in its distribution, being confined to a few situations east of St. Andrews where wave action is greatest. It may be exposed to the air for a short period at low tide, or cut off from the retreating tide in deep pools.

The annual regrowth of the lamina of *L. Cloustoni* is very characteristic and takes place between January and April. When the new blades begin to split up to the digitate form, the old blades are cast off as a whole and washed ashore. The rough surface of the perennial stipes forms an ideal position for the growth of epiphytes, and most have a thick covering of these plants the most frequent of which are *Polysiphonia urceolata*, *Membranoptera alata*, *Rhodymenia palmata*, *Phycodrys rubens*, *Ptilota plumosa*, and *Lithophyllum pustulatum* var. *Laminariae*.

The epiphyte associated with *Alaria esculenta* is *Litosiphon Laminariae*. The undergrowth generally occurring with this association consists principally of *Desmarestia* spp. and the Rhodophycean sub-littoral associations.

COMPARISONS WITH OTHER DISTRICTS.

1. The effect of wave action on zonation, and the order of disappearance with increased exposure to severe conditions, is similar to that found by others for the shores of Britain. Thus *Ascophyllum* is the first to be affected and disappears before *Fucus vesiculosus*. The Continental workers, on the other hand, usually find that *F. vesiculosus* is more sensitive to exposure than *Ascophyllum* (Zaneveld (10) and Börgesen (2)).

2. The level at which *Ascophyllum* is found in the littoral zonation varies in different districts. Cotton (3), Börgesen (2), and others find *Ascophyllum* both above and below the *F. vesiculosus* zone. Zaneveld (10), working on the Dutch coast, finds that where *Ascophyllum* is high up in the *F. vesiculosus* zone it never enters the *F. spiralis* zone. At St. Andrews, *Ascophyllum* is always high up in the *F. vesiculosus* zone and in some places does mix with *F. spiralis*. This is possibly on account of: (1) The protection against the prevailing south-west winds furnished by the cliffs. The best growth of *Ascophyllum* lies under the shelter of this cliff high up on the shore. (2) The ridges of rock lying parallel to the shore and acting as breakwaters form a second protective feature. The

force of the waves is broken at places by two of these ridges, and then the tide laps gently forward over the higher part of the littoral region, where *Ascophyllum* flourishes just below, and into the *F. spiralis* zone. At no place in the surveyed area does *Ascophyllum* dominate the shore as it does in some more sheltered districts described by other writers (Lynn (7) and Gibb (5)). *Polysiphonia fastigiata* is the common epiphyte found on *Ascophyllum* and it is always associated with it. At St. Andrews *P. fastigiata* grows equally well on *F. vesiculosus*, and so, in the area described where *Ascophyllum* is not abundant, it has a greater range than it would otherwise have if it were confined to *Ascophyllum* alone. This has not been noted by other workers, Cotton (3) stating that he only once found *P. fastigiata* on *F. vesiculosus*.

3. *Himanthalia lorea* is found to abound on the rocks over which the waves dash and break into surf. This is in agreement with what is found in other districts.

4. *Laminaria hieroglyphica* is not given by most other workers for the British coasts. The form found abundantly at St. Andrews agrees with the description given by Börgesen (2) for *L. saccharina* var. *bullata* which is included in Newton's Handbook as *L. hieroglyphica*.

5. *Laminaria Cloustoni* is found by most workers to be absent from sheltered shores and to develop with greater exposure (Gibb (5), comparison of Cumbrae and Isle of Man), while *Alaria* grows best on the most exposed shores. Thus St. Andrews is comparable to the moderately exposed shore, increasing to greater exposure out of the shelter of the Bay, where *Alaria* comes into the *Laminaria* association.

SUMMARY.

1. The spray region, situated above high-water mark, is the habitat of lichens and bryophytes.

2. The littoral region, extending between high- and low-water marks of ordinary spring tides, is successively zoned from high to low by the following associations: (a) *Pelvetia canaliculata* growing between the high-tide marks, (b) *Fucus spiralis*, (c) *Fucus vesiculosus–Ascophyllum nodosum*, (d) *Fucus serratus–Himanthalia lorea*, and (e) *Laminaria digitata–L. hieroglyphica* inhabiting the lowest part of the littoral region.

3. The sub-littoral region, below the low-water mark of spring tides, is occupied by a *Laminaria Cloustoni* association.

This work was carried on during the tenure of a Carnegie Scholarship.

REFERENCES.

(1) BAKER, S. M.: On the Causes of the Zoning of Brown Seaweeds. New Phytol., viii, p. 196, and ix, p. 54 (1909 and 1910).
(2) BÖRGESEN, F.: The Algae-vegetation of the Faeröes (1905).
(3) COTTON, A. D.: Clare Island Survey; Marine Algae. Proc. Roy. Irish Acad., xxxi, sec. 1, pt. 15 (1912).
(4) DUNN, M. D.: The Marine Algae of St. Andrews Bay. Trans. Bot. Soc. Edin., xxxii, p. 488 (1939).
(5) GIBB, D. C.: Some Marine Algal Communities of Great Cumbrae. Journ. of Ecol., xxvii, p. 364 (1939).
(6) LOWE, D. N.: Survey of the Marine Algae of the Coast of Fife. Trans. Bot. Soc. Edin., xxxi, p. 498 (1935).
(7) LYNN, M. J.: Botanical Survey of N. Ireland: Coastal Survey V. Irish Nat. Journ., iv, No. 4 (1932).
(8) RATTRAY, J.: The Distribution of the Marine Algae of the Firth of Forth. Trans. Bot. Soc. Edin., xvi, p. 420 (1886).
(9) TRAILL, G. W.: A Monograph of the Algae of the Firth of Forth.
(10) ZANEVELD, J. S.: The Littoral Zonation of some Fucaceae. Journ. of Ecol., xxv, p. 431 (1937).

NOTES ON THE GERMINATION OF SOME BRITISH ORCHIDS.

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(Read 22nd May 1941.)

In a previous paper (Downie, 1940) it was shown that the seeds of *Goodyera repens* Br. do not germinate asymbiotically in water, but germination is obtained if the cultures are inoculated by an endophytic fungus isolated from the root of the adult plant. The following notes give the results of similar experiments with some other British orchids. The initial medium, both in asymbiotic and symbiotic cultures, is water, but two of the nutrient media recommended by Knudson (1922) are included with a view to obtaining further knowledge regarding the germinating capacity of the various orchid seeds used in the experiments. It will be shown that some species germinate asymbiotically quite freely in water, some germinate freely or only sparsely in sugar solution, while others have, so far, resisted all attempts to induce germination. From a few species the fungal symbionts have been isolated, and experiments have been carried out to determine the effect of these mycorrhizal fungi not only on the seeds of their respective host plants but also on the seeds of other species of orchids.

The following were used in the experiments: *Coeloglossum viride* Hartman (*Habenaria viridis* R. Br.), *Corallorhiza innata* R. Br., *Goodyera repens* R. Br., *Gymnadenia albida* Rchb. (*Habenaria albida* R. Br.), *G. conopsea* R. Br., *Platanthera bifolia* Rchb. (*H. bifolia* R. Br.), *Listera cordata* R. Br., *L. ovata* R. Br., *Orchis maculata* L. sub-sp. *elodes* Godfery, and *O. purpurella* Stephenson (the form with unspotted leaves formerly known as *O. praetermissa* var. *pulchella* Dr.).

The experimental methods were the same as those previously described (1940), the seeds being sterilised with calcium hypochlorite and sown aseptically on agar slopes in test tubes. The distilled water cultures were duplicated, being carried out either with agar or with glass wool as the substrate. The basis of the nutrient media was Pfeffer's mineral salt solution, to which was added either dextrose alone, or dextrose and potato extract. Asymbiotic experiments are reported from the three media: (1) Distilled Water, (2) Pfeffer's solution + 1 per cent. dextrose, (3) Pfeffer's solution + 1 per cent. dextróse + potato extract. Only the first two media were used in the symbiotic experiments, the third being omitted as on potato extract mycelial growth forms a very dense mat through which the protocorms generally fail to penetrate.

Three experiments are described: (1) Asymbiotic germination, (2) Symbiotic germination in the presence of a normally associated mycorrhizal fungus, (3) Germination in the presence of symbionts obtained from other orchids.

Experiment 1.—The results of asymbiotic germination are shown in Table I.

TABLE I.

ASYMBIOTIC GERMINATION.

	Distilled Water.	Pfeffer + Dextrose.	Pfeffer + Dextrose + Potato Extract.
Coeloglossum viride .	+ + + +	+ + + +	+ + + +
Corallorhiza innata .	0	0	0
Goodyera repens . .	0	+ + + +	+ + + +
Gymnadenia albida .	0	0	0
G. conopsea . . .	+ + + +	+ + + +	+ + + +
Listera cordata . .	0	0	0
L. ovata . . .	0	0	+
Platanthera bifolia .	0	+	+ +
Orchis maculata v. *elodes*	+ + + +	+ + + +	+ + + +
O. purpurella . .	+ + + +	+ + + +	+ + + +

0 = no germination; + = very sparse; + + = sparse; + + + = fair; and + + + + = good germination.

The seeds of four orchids, *Coeloglossum viride*, *Gymnadenia conopsea*, *Orchis maculata* var. *elodes*, and *O. purpurella* germinate freely on distilled water, and it is of some interest that three of these are among our most widely distributed orchids. Four months after sowing small rounded protocorms were present in the cultures of each species, and all were about 0·4 × 0·3 mm. in size with numerous well-developed epidermal hairs. On the nutrient media germination was equally good, but the subsequent growth of the protocorms was variable. Most of the protocorms of *Coeloglossum viride* reach a length of 2·5 mm. on the Pfeffer + dextrose medium and 3 mm. on the medium containing potato extract. Apparently both media are favourable to the growth of this species. The protocorms of *Gymnadenia conopsea* attained an average size of 0·8 mm. on the Pfeffer + dextrose medium and 1 mm. on the cultures with potato extract. On the other hand, the seeds of *Orchis maculata* var. *elodes* and *O. purpurella* do not develop well on a nutrient medium containing Pfeffer's mineral salts. Growth was erratic; many protocorms barely emerged from their seed coats, and only a few attained a size equal to those of *Gymnadenia conopsea.*

No germination was obtained in the water cultures of the remaining six orchids used in the experiment. Three of them —*Corallorhiza innata*, *Gymnadenia albida*, and *Listera cordata*— proved completely unresponsive on both nutrient media. *Goodyera repens* germinates freely on sugar solutions, as already reported. *Listera ovata* and *Platanthera bifolia* germinate very sparsely, the latter developing a few protocorms on both nutritive media, the former developing only on the medium containing potato extract. In view of the fact that large numbers of seeds were sown, it would appear that five of the above species are in some way exacting in their germination requirements.

Experiment 2.—Mycorrhizal fungi associated with the roots of *Coeloglossum viride*, *Goodyera repens*, *Gymnadenia conopsea*, and *Platanthera bifolia* were isolated and cultured on potato dextrose agar. The seeds of these four orchids were sown on distilled water and on Pfeffer + dextrose, and the cultures inoculated with the corresponding mycorrhizal fungus. A comparison of the results of this symbiotic germination with those of asymbiotic conditions is shown in Table II.

Wherever asymbiotic germination occurs on a medium, the addition of the mycorrhizal fungus stimulates the growth of the protocorms. Over the same period, protocorms with fungus are at least twice the size of those on the corresponding asymbiotic medium. The chief interest, however, centres round the results obtained for *Platanthera bifolia*. As in the case of *Goodyera repens*, previously described, symbiotic germination has been obtained in water, a medium on which the seeds of *Platanthera bifolia* lie dormant, while on the nutrient solution cultures instead of only one or two proto-

TABLE II.

COMPARISON OF ASYMBIOTIC AND SYMBIOTIC GERMINATION.

	Distilled Water.		Pfeffer's Solution + Sugar.	
	− Symbiont.	+ Symbiont.	− Symbiont.	+ Symbiont.
Coeloglossum viride .	+ + + +	+ + + + S	+ + + +	+ + + + S
Goodyera repens . .	0	+ + +	+ + + +	+ + + + S
Gymnadenia conopsea .	+ + + +	+ + + + S	+ + + +	+ + + + S
Platanthera bifolia .	0	+ + +	+	+ + + + S

S = stimulation in growth of protocorms on media where germination already recorded in the absence of the symbiont. Other symbols as in Table I.

corms developing, numerous seeds germinate in the presence of the fungus. A further interest attaches to the fact that two endophytic fungi were isolated from this species, each from individual plants growing in widely separated areas in the North of Scotland. The endophytes, which, for convenience, may be called A and B, are apparently morphologically distinct. The presence of either of these symbionts initiates germination in the water cultures and on the nutrient media. Symbiont A is more effective; the large majority of the seeds germinate in all the tubes containing this fungus. Germination results are also good with symbiont B, but the number of seeds stimulated is not so great. It is perhaps of some significance that in the area in which symbiont A is the endophyte, the orchid is much more abundant than in the area where symbiont B forms the mycorrhizal partner of the plant.

Experiment 3.—The mycorrhizal fungi isolated from *Coeloglossum viride*, *Goodyera repens*, and *Platanthera bifolia* (A) and (B) were introduced into experimental tubes containing the seeds of six different orchids with a view to testing the specificity of the symbionts associated with our native species. This experiment follows the work of Curtis (1939), who has shown for certain species that no specificity between fungus and orchid exists. Only one British species, however, is included in the investigation carried out by Curtis. The results of my own experiments are shown in Table III.

TABLE III.

GERMINATION WITH DIFFERENT SYMBIONTS.

	SYMBIONTS.							
	C. viride.		*G. repens.*		*P. bifolia* (A).		*P. bifolia* (B).	
	Distilled Water.	Pfeffer + Dextrose.	Distilled Water.	Pfeffer + Dextrose.	Distilled Water.	Pfeffer + Dextrose.	Distilled Water.	Pfeffer + Dextrose.
Coeloglossum viride . .	+ + + + S	+ + + + S	–	–	+ + + + S	+ + + + S	–	–
Goodyera repens . .	+ + +	+ + + + S	+ + +	+ + + + S	+ + + +	+ + + + S	0	+ + + +
Gymnadenia conopsea .	–	–	+ + + + S	+ + + + S	+ + + + S	+ + + + S	–	–
Platanthera bifolia . .	0	0	+ +	+ + + + S	+ + +	+ + + + S	+ +	+ + + S
Orchis maculata v. *elodes* .	+ + + + S	+ + + + S	+ + + + S	+ + + + S	+ + + + S	–	–	–
O. purpurella . . .	+ + + + S	+ + + + S	+ + + + S	+ + + + S	+ + + + S	–	–	–

S = Stimulation in growth of protocorms on media where germination already recorded in the absence of the endophyte; – = experiment not performed; other symbols as in Table I.

The four orchids *Coeloglossum viride*, *Gymnadenia conopsea*, *Orchis maculata* var. *elodes*, and *O. purpurella* which germinate asymbiotically in water show acceleration in the growth of their protocorms in symbiosis with one or more of the endophytes introduced into the culture tubes. These orchids, which are not exacting in their germination requirements, gain an obvious growth stimulus from a mycorrhizal association, and this stimulus can be obtained from a number of different orchid endophytes. Apparently growth requirements are not of a specific kind, at least in the early stages of protocorm development. Germination of the seeds of *Goodyera repens* in water is not only initiated by its own endophyte but by that of *Coeloglossum viride* and by endophyte (A) from *Platanthera bifolia*. Equally good germination is obtained in the presence of its own endophyte and that of *Coeloglossum viride*, but with symbiont (A) from *Platanthera bifolia* the germination is even better. The seeds of *Platanthera bifolia* germinate sparsely with the symbiont of *Goodyera repens*, but remain dormant in the cultures containing the endophyte of *Coeloglossum viride*. The results obtained on the nutrient media confirm those obtained in water.

The above data support the claim put forward by Curtis that no specificity exists between orchid and mycorrhizal fungus. The present writer would agree that this claim is probably of general application to the conditions prevailing in adult plants, but would be reluctant to accept such a claim as universal where the germination requirements of orchids are concerned. It may yet be found that a few orchids do require a specific fungus to stimulate germination.

DESCRIPTION OF ORCHID ENDOPHYTES.

All the orchid symbionts so far isolated conform to the description of the genus Rhizoctonia. The mycelium, at first white, becomes cream coloured or yellow as the filaments mature. Moniliform filaments give rise to the spore cells, which are generally grouped in small or large masses, termed sporodochia by Curtis. The following is a brief description of the four symbionts used in Experiment 3. It is hoped that a more detailed systematic account of these fungi will follow at a later date.

Symbiont of *Coeloglossum viride*: mycelium white, later becoming cream coloured. Sporodochia cream coloured, coalescing. Hyphae 6–7 μ in diameter. Spores elongate, 22–32 μ by 11–15 μ.

Symbiont of *Goodyera repens*: mycelium cream coloured to pale yellow. Sporodochia cream coloured, coalescing. Hyphae 6–7 μ in diameter. Spores elongate, 21–25 μ by 12–16 μ.

Symbiont of *Platanthera bifolia* (A): mycelium cream coloured, numerous aerial hyphae. Sporodochia cream coloured, coalescing. Hyphae 6–7 μ in diameter. Spores elongate, 20–28 μ by 13–18 μ.

Symbiont of *Platanthera bifolia* (B): mycelium white, becoming buff coloured. Sporodochia cream coloured, waxy, isolated, generally 1–2 mm. in diameter, but in older test tube cultures some masses are 1 cm. in extent. Hyphae 6–7 μ in diameter. Spores 21–32 μ by 18–24 μ.

The first three symbionts closely resemble one another and all grow well on potato dextroses agar. The fourth symbiont, with its isolated sporodochia and more rounded spores, is quite distinct. It grows slowly on pototo dextrose agar, developing more rapidly if mineral nutrient salts are also present in the medium.

Discussion.

In recent years experimental studies on symbiosis of orchid and fungus endophyte have centred round the rôle of the fungus in the germination of the orchid. Although this is only part of the problem of symbiosis, interesting results are accruing as to the effects of a mycorrhizal association at this critical stage in the life-history of orchids. The capacity for germination is very variable. Too often it is taken for granted that orchid seeds are difficult to germinate, and the available data invariably refer to the results of germination on nutrient media, but seldom on water. Seeds of most plants commonly germinate in water at suitable termperatures and, under conditions obtaining in the field, these are accepted as the two most important factors. The obvious starting-point in any germination experiment is, therefore, the reaction of the seed in water. This has been overlooked in most experimental work on orchids, especially where symbiotic germination is under consideration. The fact that a fungus is involved in orchid symbiosis has determined the addition to the culture medium of a carbohydrate such as starch, and, in an endeavour to ensure the balanced growth of the fungus and the embryo of the higher plant, nutrient mineral salts have also been included. This is unfortunate, firstly, because the mineral constituents employed may prove detrimental to the development of either or both organisms, as indicated in the foregoing asymbiotic experiments with *Orchis maculata* var. *elodes* and *O. purpurella*, and, secondly, because the inclusion of starch introduces a new factor in that many fungi possess the faculty of hydrolysing starch into water soluble components such as sugars. All germination experiments should be dissociated as far as possible from later records on the growth of the protocorms. Orchid seeds, though small, contain considerable reserves of food material, and it has been demonstrated that some germinate freely in water without the symbiont, others with the symbiont, so that the addition of nutrient substances appears unnecessary. It is true that media which include nutrient salts and sugar can profitably be used in conjunction with the cultures in water, as additional data may then be obtained of the asymbiotic germination capacity of the orchid species under investigation, while in the symbiotic cultures the consequent acceleration in the growth of both organisms admirably confirms the less spectacular results in water alone. The use of starch in the medium is at no time helpful. It contributes nothing to asymbiotic germination, and in a great many cases obscures the issue in the symbiotic experiments, as the fungus introduced may be a starch hydrolysing agent and the seed under investigation may belong to the group which germinates freely in sugar solutions. The action of a mycorrhizal fungus which initiates germination of the seed in water is probably quite different from the action of a saprophytic fungus which in hydrolysing the insoluble carbohydrates of the substrate makes available the soluble components which stimulate the germination of at least some orchid seeds. The end result, when working with such seed, is admittedly similar, but the incidence of the fungus, if not the chemical changes as well, are dissimilar, and this difference has been obscured in the past by the constant inclusion of starch in the medium employed by all previous investigators when examining the effect of a fungus, whether orchid endophyte or common soil saprophyte, on orchid seed germination.

The investigations carried out by Curtis (1939) are of special interest since he claims that the relationship between orchid and fungus is not specific. He isolated a large number of orchid endophytes, including four from one species of orchid, and he has demonstrated that the seeds of several orchid species are stimulated to develop in conjunction with a number of different species of Rhizoctonia. In certain instances the Rhizoctonia obtained from an adult plant failed to stimulate the corresponding seed, yet this seed was stimulated by the endophyte from some other orchid. His work is open, however, to the same criticism as that of earlier investigators on symbiotic germination since he includes starch in his basic medium, and five out of the eight species used in his experiments germinated on sugar solution as shown by his asymbiotic controls. Of the three species, *Cypripedium reginae*, *Habenaria leucophaea*, and *Liparis Loeselii*, which do not germinate asymbiotically on the sugar-containing medium, he succeeded in germinating only the first by means of two species of Rhizoctonia, neither of them found in association with the Cypripedium. The only endophyte isolated from *Cypripedium reginae* was *Rhizoctonia sclerotica*, and this failed to stimulate germination. But as Curtis has himself argued, more than one fungus may enter the orchid root, but only one may possess the faculty of stimulating germination. Thus it remains to be seen whether a second endophyte may not be isolated from *Cypripedium reginae* which will initiate the germination of its seeds. The interesting point is that the seeds of an orchid, exacting in its germination requirements, have been stimulated by two different species of Rhizoctonia, and these presumably entered into mycorrhizal association with their host. This suggests the need of a symbiont for the germination of this orchid, although Curtis apparently supports Knudson's view that no beneficial symbiosis between orchid and fungus exists. Curtis obtained no germination with the seeds of *Habenaria leucophaea*, although he isolated four fungi from this orchid. Three of them failed to stimulate germination, but no record is given of the fourth.

SUMMARY.

Basic experiments on orchid seed germination, whether asymbiotic or symbiotic, should be carried out in water.

Orchid seeds which do not germinate asymbiotically in water may be stimulated to develop in this medium by means of a fungus which enters into mycorrhizal association with the adult plant, for example, *Goodyera repens* and *Platanthera bifolia.*

An endophyte obtained from one orchid species may initiate the germination of the seeds of another species in water. Symbiotic germination is therefore not necessarily specific. The endophyte of *Habenaria bifolia*, for example, stimulates the seeds of *Goodyera repens* and vice versa.

REFERENCES.

CURTIS, J. T. (1939): The Relation of Specificity of Orchid Mycorrhizal Fungi to the Problem of Symbiosis. Amer. Journ. Bot., xxvi, 390–399.

DOWNIE, D. G. (1940): On the Germination and Growth of *Goodyera repens.* Trans. Bot. Soc. Edin., xxxiii, 36–51.

KNUDSON, L. (1922): Non-symbiotic Germination of Orchid Seeds. Bot. Gaz., lxxiii, 1–25.

THE EFFECT OF LOW TEMPERATURE ON TROPICAL PLANTS.

By R. J. D. GRAHAM, M.A., D.Sc.

(Read 23rd October 1941.)

Opportunity on a large scale to study the effect of low temperature on tropical plants seldom occurs. The following records of observations made in St. Andrews are, therefore, of considerable interest.

The plants constituted the contents of the borders in the Tropical Stove House, normally kept at a night temperature about 60° F., and the Intermediate Stove House maintained at a night temperature of 55° F. All were established plants which had been grown in the soil of the borders for many years. The exposure took place between 25th October 1940 and 15th November 1940, and the duration of the exposure was 14 days in the case of the Intermediate Stove and 22 days for the Tropical Stove. During these periods there was no glass in the roof nor in the partitions of the two houses. The temperature records for the period have been furnished through the courtesy of the Burgh Engineer.

RECORDS OF MAXIMUM AND MINIMUM TEMPERATURES AT ST. ANDREWS RECORDING STATION.

Date.	Max.	Min.	Date.	Max.	Min.
Oct. 25	48	38	Nov. 5	48	29
,, 26	48	38	,, 6	47	32
,, 27	49	45	,, 7	47	34
,, 28	50	37	,, 8	45	36
,, 29	40	37	,, 9	47	41
,, 30	47	38	,, 10	49	42
,, 31	50	44	,, 11	46	34
Nov. 1	50	43	,, 12	44	37
,, 2	52	43	,, 13	47	41
,, 3	47	46	,, 14	47	38
,, 4	50	31	,, 15	46	32

From these records it will be observed that there was a period of sharp overnight frost from 4th–6th November to which the contents of both houses were subjected. That plants were killed by this treatment was to be expected, but that the number of fatalities reached no higher figure than 33 per cent. is remarkable, that over 38 per cent. of the plants withstood the shock either completely or with only the loss of their leaves is surprising. In the list, together with the name of the plant, the geographical distribution as given in Index Kewensis is recorded for reference. From the countries cited it is obvious that country of origin has but little to do in determining resistance to cold, but that other causes, amongst which the water content as determined by the condition of growth at the time of the exposure to cold, play a more important part.

STOVE PLANTS EXPOSED TO COLD AT THE UNIVERSITY BOTANIC GARDEN, ST. ANDREWS.

List 1. *Plants killed by cold.*

Name.	Native Country.
* *Clusia* sp.	Am. trop.
Norantea guianensis	Am. trop.
Theobroma Cacao	Am. trop.
Guaiacum officinale	Ind. occ.
Leea coccinea	Burma.
Trachylobium Hornemannianum	Afr. trop.
Desmodium incanum	Ind. occ.
Passiflora edulis	Am. trop.
* *Kopsia fruticosa*	Burma, Malaya.
Clerodendron calamitosum	Malaya.
Anemopaegma racemosum	Bras.
* *Pogostemon Heyneanus*	Ind. or.
Ixora coccinea	As. trop.
* *Vanilla palmarum*	Bras.

List 2. *Plants damaged by cold.*

Name.	Native Country.	Extent of Damage.
Hibiscus schizopetalus	Afr. trop.	Defoliated, cut slightly.
* *Serjania cuspidata*	Bras.	Cut to ground.
* *Quisqualis indica*	Malaya.	Cut to ground.
* *Terminalia Benzoin*	Malaya.	Cut to main stem.
* *Cerbera Tanghin*	Madag.	Cut slightly.
Lankesteria elegans	Afr. trop.	Cut to ground.
Whitfieldia lateritia	Afr. trop.	Cut to ground.
* *Bignonia ornata*	Bras.	Cut slightly.
Dracaena surculosa	Afr. trop.	Cut slightly.
Musa Cavendishii	China.	Cut to ground.
* *Hamelia patens*	Am. trop.	Cut to main stem.

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* Plants in Tropical Stove exposed to cold for 22 days.

List 3. *Plants undamaged by cold, occasionally defoliated.*

Name.	Native Country.	
Hibiscus rosa-sinensis vars. except double yellow	Geront. trop.	
Hibiscus rosa-sinensis var. double yellow		Defoliated.
* *Hibiscus Reevesii*		
* *Citrus decumana*	As. trop.	
* *Citrus nobilis*	As. trop.	
* *Murraya exotica*	As. et Austral. trop.	
Triphasia aurantiola	As. trop.	
* *Mimosa Speggazzinii*	Reg. Argent.	
* *Acacia sphaerocephala*	Mexico.	Defoliated.
Jasminum nitidum		Defoliated.
* *Tabernaemontana coronaria*	Ind. or.	Defoliated.
* *Brunfelsia calycina eximia*		
Jacobinia magnifica	Bras.	
* *Phyllanthus nivosus*	Ins. Pacif.	
Piper nigrum	In. or., Malaya.	
Ficus elastica	As. trop.	
* *Ficus repens*	In. or.	
Rondeletia odorata	Cuba, Mexico.	Defoliated.
Monstera deliciosa	Am. trop.	

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* Plants in Tropical Stove exposed to cold for 22 days.

New Species of Alpine Primulas.

By W. Wright Smith and H. R. Fletcher.

(Read 23rd October 1941.)

In the course of a revision of five important sections of the genus, and in the analysis of recently received material belonging to these sections, a number of new species has come to light. The following are here described:—

Primula assamica H. R. Fletcher (sect. Farinosae).
Primula aureata H. R. Fletcher (sect. Petiolares).
Primula bhutanica H. R. Fletcher (sect. Petiolares).
Primula cerina H. R. Fletcher (sect. Nivales).
Primula Comberi W. W. Sm. (sect. Farinosae).
Primula Fernaldiana W. W. Sm. (sect. Farinosae).
Primula Geraldinae W. W. Sm. (sect. Minutissimae).
Primula praetermissa W. W. Sm. (sect. Minutissimae).
Primula rimicola W. W. Sm. (sect. Minutissimae).
Primula Sharmae H. R. Fletcher (sect. Farinosae).
Primula stenodonta Balf. f. MS. descript. W. W. Sm. et Fletcher (sect. Candelabra).

Primula assamica H. R. Fletcher. Spec. nov.

Species inter affines himalayenses cum *P. Schlagintweitiana* Pax atque *P. Sharmae* H. R. Fletcher comparanda; ab ambabus habitu compacto, scapo folia aequante vel paulo superante inter alia multa cognoscenda; affinitas autem cum *P. Jaffreyana* King esse videtur sed remotior.

Planta magnitudine mediocris, rhizomate brevi crasso, basi foliis vetustis emarcidis circumdata. Folia petiolo incluso ad 5 cm. longa, ad 1·5 cm. lata, spathulata vel spathulato-oblonga, apice rotundata, basi cito attenuata in petiolum membranaceo-alatum in adultis laminam fere aequantem, margine denticulata vel eroso-denticulata, supra glandulis farinosis conspersa itaque scabridula, infra farina copiosa albida vel pallido-lutea induta, in sicco membranacea, nervis supra inconspicuis, costa infra atque nervis 6–7-paribus prominulis. Scapus ad 5 cm. altus, subsparsim farinosus umbellam 2–6-floram gerens. Bracteae lineari-lanceolatae, circ. 1 cm. longae, plus minusve involutae; pedicelli 3–4 mm. longi,

leviter farinosi. Calyx viridis glandulis farinosis extra conspersus, intra multo densius, 6–10 mm. longus, in lobos lanceolatos acuminatos saepe apice paulo patentes ad duas partes divisus. Corolla pallido-purpurea, oculo magno albo; tubus anguste cylindricus, apice paululo ampliatus, in floribus longistylis vulgo calycem minime superans sed nunc fere duplo; limbus 1·5–2 cm. diametro; lobi obcordati, 6–7 mm. longi et lati, alte emarginati, plus minusve patentes. Stamina in floribus longistylis prope basim tubi corollini inserta. Stylus calycem aequans. Capsula deest.

"INDIA. Assam Himalaya, on the Orka La, Bhutan frontier. Alt. 12,000–14,000 feet. Flowers mauve, with large white eye. Inflorescence and foliage mealy, under-surface of leaves showing white with meal. On steep alpine slopes facing the sun, where it is dwarfed and compact, and on damper, shadier portions on the cliffs, where it grows much more lush, usually with darker flowers. Common at 13,000 feet alpine region. 8th June 1938." *F. Kingdon Ward*, No. 13715. Type in Herb. Brit. Mus.

The relationship of this species is with certain N.W. Himalayan plants such as *P. Schlagintweitiana* Pax. Among Eastern Himalayan species there does not appear to be anything closely allied to it.

Primula aureata H. R. Fletcher in Gard. Illus., lxiii, p. 283 (1941). Descript. amplif.

Species aliquatenus affinis *P. bracteosae* Craib et *P. Boothii* Craib; planta tota valde farinosa, floribus ad limbum aurantiacis nec roseis nec lilacinis distinguitur.

Planta sociis supra citatis magnitudine similis, squamis basalibus sub anthesin deficientibus. Folia late spathulata vel oblongo-spathulata, ad 10 cm. longa, ad 2 cm. lata, apice rotundata, basi sensim angustata in petiolum late membranaceo-alatum nunc fere obsoletum, alte atque irregulariter dentata vel interdum fere laciniata, utrinque albo-farinosa, infra densius, petiolo costaque nervisque plus minusve rubescentibus. Scapus valde farinosus, brevissimus, inter folia occultus, umbellam ad 10-floram gerens; bracteae lineari-lanceolatae, dense farinosae, ut pedicelli ad 2 cm. longi. Calyx campanulatus, extra farina indutus, intra sparsius, ad 14 mm.

longus, in lobos ovatos acuminatos apice recurvos ad medium divisus. Corolla textura firma vel etiam subcoriacea, extra dense farinosa; tubus pallido-flava, calycem duplo superans; limbus ad 4 cm. diametro, parte distali colore lactea, parte interiore usque ad os saturate flava vel aurantiaca; lobi late obovati, margine alte atque subirregulariter dentati. Stamina in floribus longistylis ad medium tubum inserta. Stylus manifeste exsertus.

EASTERN HIMALAYA—Sikkim?. Type in Herb. Edin.

Almost certainly within Sikkim but exact locality unknown. Raised from seed received from Darjeeling. There is no suggestion of hybridity nor is there any combination of the known species of Petiolares section in the Himalaya likely to produce a result like *P. aureata*. But no material of it in any herbarium has come to light. These early-flowering species in the Himalaya are not yet fully known, and collectors would need to travel in April and the beginning of May into regions still mostly under snow.

Primula bhutanica H. R. Fletcher in Gard. Illus., lxiii, p. 312 (1941). Descript. amplif.

Species valde affinis *P. Whitei* W. W. Sm.; lobis corollinis semper tridentatis nec crenulatis, lobis calycinis integris nec fimbriatim dentatis differt.

Planta gemmam hibernantem ad modum *P. Whitei* formans, sub anthesin squamis imbricatis persistentibus farinosis ovatis vel ellipticis vel oblongis ad 4 cm. longis ad 1 cm. latis basi cincta. Folia tempore florendi spathulata vel oblongo-spathulata, ad 10 cm. longa petiolo incluso, ad 3 cm. lata, apice acuta vel rotundata, basi in petiolum membranaceo-alatum interdum fere obsoletum sensim angustata, margine irregulariter dentata, primo utrinque farinosa, deinde supra fere efarinosa, subtus farina sparsa vel glandulis farinipotentibus munita; folia in speciminibus fructiferis ad 20 cm. longa, ad 5 cm. lata, bene dentata, petiolo satis evoluto costaque rubescentibus. Scapus primo inter folia celatus, tandem plus minusve evolutus et interdum ad 8 cm. altus, praesertim ad apicem farinosus, umbellam ad 10-floram gerens; bracteae lineari-lanceolatae, basi dilatatae, ad 1 cm. longae, sparsim farinosae; pedicelli ad 4 cm. longi, leviter farinosi. Calyx campanulatus, 1 cm. longus, utrinque tenuiter farinosus, in

lobos ovatos acutos vel acuminatos vulgo integros ad medium divisus. Corolla pallido-coerulea, oculo albo nunc viridi-flavi-suffuso; tubus calycem duplo superans; limbus 2–3 cm. diametro; lobi patentes, obovati, semper alte tridentati. Stamina in floribus brevistylis paulo infra os corollinum inserta, in longistylis ad medium tubum. Stylus tubum corollinum aequans, in brevistylis tantum dimidium.

"E. Bhutan. On the Chöling La, Gamri Chu (also Mera and Sakden). Alt. 11,000–13,000 feet. A beautiful delft-blue primula, first found where snow was still lying, the primula being in flower beside, but not in, the snow. On a south face it was growing with 1167. Eye very slightly yellowish green round which is a white margin. In damp mossy soil, in both N. and S. faces, usually shaded partially. Seen well up to 13,000 feet in conifer forest. 9.3.36." *Ludlow and Sherriff*, No. 1166—type.

"On the Chöling La, Gamri Chu. Alt. 11,500 feet. Flowers over. Specimen taken from the same spot and elevation as No. 1166. Leaves and buds both covered densely with thick farina, leaves on both surfaces. Only the pink extremely outer winter-bud leaves have no farina except a little at their bases inside. On damp mossy ground under bamboos and rhododendrons (snow will later fall and lie here for some time). 16.11.36." *Ludlow and Sherriff*, No. 2864.

"Sakden. Alt. 10,000 feet. 13.3.36." *Ludlow and Sherriff*, No. 1215.

"S. Tibet. Lung, Chayul Chu. Alt. 9200 feet. Growing on wet moss always beside a stream. 28.4.36." *Ludlow and Sherriff*, No. 1379.

"Lung, Chayul Chu. Alt. 9000–12,000 feet. Delft-blue, pale greenish eye, surrounded by white. Farina evident on under-surface of corolla and on young leaves. Specimens collected from about 12,000 feet, where the primula was still in full bloom. On wet mossy rocks, always beside a cascade. 29.4.36." *Ludlow and Sherriff*, No. 1388.

"Lepo, Nyam Jang Chu. Alt. 11,000 feet. Growing in patches up to a foot across making a grand sight. Damp mossy ground in partial shade. 7.4.36." *Ludlow and Sherriff*, No. 1291.

"On the Bimbi La, Tsari. Alt. 13,500 feet. Very common on mossy banks in mixed forest or among rhododendrons. 12.9.36." *Ludlow and Sherriff*, No. 2582.

"Sanguti, Tsari Chu. Alt. 13,000 feet. Very common in masses under juniper and rhododendron forest. 17.5.36." *Ludlow and Sherriff*, No. 1605.

"ASSAM. On the Se La. Alt. 13,000 feet. Flowers pale bluish violet, with large white eye.. Fragrant. Passing over. In Abies-Rhododendron forest, on steep banks. 3.6.35." *Kingdon Ward*, No. 11603.

"On the Manda La. Alt. 11,000 feet. In fruit. 19.5.35." *Kingdon Ward*, No. 11478.

Kingdon Ward first found this plant on the Manda La, in Assam, in 1935. Since that time Ludlow and Sherriff have collected it on several occasions in E. Bhutan and S.E. Tibet and have introduced it into cultivation. At first, both in the garden and in the herbarium, the plant was confused with *P. Whitei*. In the Edinburgh Herbarium there is ample material of true *P. Whitei* and the plant now to be called *P. bhutanica*. The material is perfectly consistent, and the two plants are at once separable by the characters of the calyx and corolla lobes. In *P. bhutanica* the calyx lobes are usually quite entire; if occasionally they develop an odd tooth, this is very short and in no way comparable to the fine fimbriation of the calyx lobes of the other plant. The corolla lobes of *P. Whitei* are crenulate and never show the three large teeth so characteristic of *P. bhutanica*, which has now been in cultivation for the past four years and during this time has shown no variation in character.

Primula cerina H. R. Fletcher. Spec. nov.

Species haec ex affinitate *P. Purdomii* Craib esse videtur sed minor, imprimis floribus flavis separata, autem foliis oblanceolatis subregulariter serratulis, petiolis gracilibus laminam aequantibus recedit.

Planta ad 10 cm. alta, rhizomate crasso brevi praedita. Folia carnosula, spathulata; lamina ad 5 cm. longa, circ. 1 cm. lata, apice rotundata vel nunc acuta, basi in petiolum ad 2·5 cm. longum paulo alatum sensim angustata, margine crenato-serrata, utrinque glandulis biseptatis farini-potentibus bene munita, infra glauca nervis valde obscuris. Scapus, bracteae, pedicelli, calyx glandulis iisdem bene obsiti. Scapus

folia duplo superat, umbellam simplicem ad 6-floram gerens; bracteae ad 5 mm. longae, lineari-lanceolatae, basi latiusculae; pedicelli ad 7 mm. longi. Calyx tubulosus, 7–9 mm. longus, in lobos anguste ovatos vel late lanceolatos apice acutos vel obtusos ad medium vel paulo ultra fissus. Corollae flavae tubus calyce sesquilongior, in floribus brevistylis supra medium sensim ampliatus; limbus 1·5 cm. diametro annulo conspicuo; lobi late elliptici vel subrotundati, integri vel nunc levissime emarginati. Stamina in floribus brevistylis ad medium tubum inserta; stylus 2 mm. longus; ovarium 1·5 mm. diametro. Capsula calycem aequans vel paulo longior, valvis 5 dehiscens.

S. W. SZECHUAN. Djesi-La and Djesi-Longba, south of Tatsienlu, on grassy banks, flowers yellow. Alt. 4400 m. June–July 1929. *J. F. Rock*, 17702—type.

Among the typical Nivalids of Western China, the only other species recorded with yellow flowers is *P. orbicularis* Hemsl. which is quite unlike *P. cerina*. The latter appears at first sight to be almost efarinose, but leaves, scape, and calyx are closely beset with capitate farinipotent glands, and the plant in certain conditions may quite well be farinose.

Primula Comberi W. W. Sm. Spec. nov.

Species affinis *P. decipienti* Duby a qua corollae tubo elongato calycem duplo superante imprimis differt.

Planta ad 10 cm. alta, rhizomate crasso brevi. Folia in sicco membranacea vel tenuiter papyracea, oblongo-spathulata vel spathulata vel subobovata, ad 4 cm. longa petiolo incluso, ad 1·2 cm. lata, apice obtusa vel rotundata, basi in petiolum brevem late alatum nunc fere obsoletum angustata, margine crenato-dentata, supra efarinosa vel glandulis farinipotentibus conspersa, infra dense albo-farinosa, costa media prominente, venis primariis 5–6-paribus subconspicuis nunc farina fere occultis. Scapus ad 10 cm. altus, vulgo flores 3–6 gerens, apice dense farinosus, ceterum multo sparsius. Bracteae 5-10 mm. longae, lineari-lanceolatae vel subulatae, basi latiusculae, gibbosae, farinosae; pedicelli 2–4 mm. longi, bene farinosi, in fructu ad 2·5 cm. aucti. Calyx 8–10 mm. longus, tubuloso-campanulatus, extra farina conspersus, intra valde farinosus, in lobos oblongos vel oblongo-lanceolatos apice obtusos vel fere rotundatos glandulo-ciliatos ad medium fissus. Corolla pallido-lilacina, annulata; tubus cylindricus,

calycem vulgo duplo superans; limbus ad 2 cm. diametro; lobi obcordati, ad 8 mm. longi et lati, alte emarginati. Stamina ad partem tertiam superiorem inserta, floribus plus minusve monomorphicis. Stylus longitudine varians, stamina paulo superans, nunc ad annulum pertinens, nunc bene exsertus. Capsula longitudine varia; ex collectore calycem valde superans sed in speciminibus Elwesianis (Herb. Kew.) calycem subaequans.

ARGENTINA. Arroyo Las Lajas. Alt. 5000–6000 feet. In bogs and side of river in peaty soil. Flowers pale lilac. 12.12.1925. *H. F. Comber*, No. 286—*type* in Herb. Edin.

CHILI. Southern Cordillera. Lat. 39° S. Feb. 1896. Vergarae in Herb. Kew.

CHILI-ARGENTINE FRONTIER. Quillen Pass about 5000 feet. A scarce plant here in marshy ground. 4.2.02. Elwes in Herb. Kew. (In fruit only.) Percy Rosales Pass. In marsh. 3500 ft. 15.2.02. Elwes in Herb. Kew. (In fruit only.)

This South American species is a close ally of *P. decipiens* Duby. It is at once distinguished by the long corolla tube, which is equal to twice the calyx, and by its much less capitate inflorescence. These characters are maintained in cultivation. *P. decipiens* Duby, cultivated from seed obtained from the Falkland Islands, retains also in cultivation a compact inflorescence and a corolla tube which does not exceed the calyx in length. Neither of them agree with *P. magellanica* Lehm., which is a plant of doubtful origin. For discussion as to choice of Duby's name for the Falkland Islands plant see Fernald in Rhodora, xxx (1928), p. 74.

Mr. H. F. Comber writes me as follows: "I first encountered this Primula in the mountain range east of Lago Alumine (about Lat. 41° S.) on my first entry into a huge volcanic crater at the northern foot of Palau Mahuida. This crater is miles across, containing thickets of *Nothofagus antarctica* (my prostrate form), *Berberis chillanensis* and *B. empetrifolia*, *Chiliotrichum rosmarinifolium* and several dwarf Pernettyas near the bogs and stream-sides. At one end is the Laguna de Palau. The lake is reputedly very deep—seen from 2000 feet above it is very nearly black in the middle, and is apparently the deepest hole of this old crater. The main stream, shown on some maps as 'Arroyo Las Lajas' or 'Arroyo Las Lajitas,' rises in this lake, wanders round and eventually leaves the crater through a deep rift or gorge. There was also in the crater a strong mineral spring, known as 'Bano de Palau,' and it was west of this that the Primula grew best, on the steep, almost inaccessible bank of a tributary stream from the west, which flowed below and at the side of a peat bog. I believe that the guanacos, and cattle especially, which came in later in the year, ate it freely, for only in this difficult place could I get seeds in January. Later I also saw many small rosettes in boggy places on 'Pampa Lonco Loan' to the west, nearer Lago Alumine, but this was in sheep and goat country, and as they don't leave much for seed, I didn't go back there. I remember particularly your comment on the length of the capsules of some of these plants, though whether the contrast was between *farinosa* and *magellanica*, or *magellanica* and my plant I cannot now say. Mine had long, almost 'nivalid' capsules. Lago Alumine is well on the Argentine side of the Andes, and Palau Mahuida well on the east of Alumine, so my Primula 286 is very definitely Argentine. Lago Alumine is of considerable size and is easily found on most maps. I also recollect seeing Primula rosettes in hummocks in peat and sphagnum bogs in Quelhuenco, between the western end of Lago Lolog and the Chilean border. Opazo (my peon) also collected Primula (Comber 1150) in 'Arroyo Manzano' which is N. of Palau Mahuida. Both these places are in the Argentine."

I have seen very adequate material of *P. decipiens* Duby from the Falkland Islands as well as from Fuegia, from the province of Magallanes in Patagonia, from Cape Horn, and from the Straits of Magellan. All this material is consistent in showing very compact inflorescences and short corolla-tube as indicated in Duby's original figure. The well-known authority on the flora of that region, Professor Skottsberg of Göteborg, wrote to me in 1929 as follows: "When I was in Stockholm the other day I called at the Museum and went through the entire material of *Primula magellanica* [*decipiens*]—all my specimens are there, among others. I have collected the plant in the Falklands as well as in Patagonia and Fuegia. As a rule, the specimens from the continent are larger, that is to say taller than the other, but I have specimens from there that do not at all exceed the island ones in size. The size and shape of the leaves are slightly variable, just as in most plants, the petiole longer or shorter, sometimes distinctly lengthened in the fruiting stage, the serrature is more or less coarse, but neither in these respects nor in the shape and size of the flower have I been able to discover any characters liable to allow of a distinction. But a species with a fairly wide distribution is almost sure to consist of races, and when seeds are gathered in two places, probably in each case from a group of specimens growing together, one may very well expect to find certain differences between the two lots. I know that very large and sturdy plants of this primrose have been gathered in the Falklands years ago, most likely in good soil, but good soil produces good grass, and the type of meadow where Primula grew in profusion is stocked with sheep—the Falkland camp is said to have changed much in the last fifty years."

P. Comberi is found much farther to the north and would appear to range between 38° and 41° S. Lat. on the Chili-Argentine frontiers. The distinction in the floral characters between these two is similar to that between *P. algida* Adam and *P. auriculata* Lamk. and cannot be attributed to the reaction of the same species to what are presumably different climatic conditions.

Primula Fernaldiana W. W. Sm. Spec. nov.

Species ex affinitate *P. Knuthianae* Pax a qua foliis subintegris, calyce minore, corollae tubo longiore, fructu calycem fere duplo superante divergit.

Planta farinosa, ad 35 cm. alta, rhizomate brevi. Folia 6–13 cm. longa, 1–3·5 cm. lata; lamina membranacea, oblanceolata vel obovata, apice rotundata, basi in petiolum circ. 2·5 cm. longum alatum haud bene discretum sensim angustata, integra vel nunc distanter atque obscure denticulata, supra efarinosa, infra farina pallido-flava dense induta; costa nervique 8–10-paria subtus conspicui. Scapus ad 35 cm. altus, efarinosus, umbellam simplicem 5–10-floram gerens; bracteae 3 mm. longae, lineares, leviter farinosae; pedicelli ad 4 cm. longi, apice farinosi. Calyx campanulatus, 5–6 mm. longus, utrinque dense albo-farinosus, prominenter 5-nervius, in lobos oblongo-lanceolatos obtusos circ. ad medium divisus. Corolla caeruleo-purpurea; tubus anguste cylindricus calycem

duplo vel triplo excedens; limbus bene annulatus, 1·5–2 cm. diametro; lobi 7 mm. longi et lati, alte obcordati. Stamina cum antheris 2 mm. longa, 5 mm. supra basim tubi inserta (in floribus longistylis). Stylus 7 mm. longus. Capsula calycem fere duplo superans, valvis 5 dehiscens.

"West China: S. W. Szechwan, at Muti Konka, east of Yalung. Alpine-regions at 12,500 feet. Flowers bluish purple. Rare. May–June 1932." *J. F. Rock*, No. 23682. Type. Same locality in fruit. Sept. 1932. *J. F. Rock*, No. 24291.

This Szechwan species has its nearest relative in *P. Knuthiana* Pax from the province of Shensi. It differs in the foliage characters, in the calyx and in the corolla, and particularly in the elongate fruit. The material collected by Rock was at first identified with *P. pulchella* Franch., to which it bears some points of resemblance. The specific name is a tribute to Professor M. L. Fernald of Harvard, who has elucidated so fully the American species of the section Farinosae.

Primula Geraldinae W. W. Sm. Spec. nov.

Species valde affinis *P. rhodochroae* W. W. Sm. a qua foliis tenuiter serratulis, farina flava nec alba infra indutis, corolla multo majore inter alia distat; ut in *P. rhodochroa* calyx tubum corollinum fere aequat.

Planta pusilla, rhizomate brevi crassiusculo, basi foliis vetustis emarcidis circumdata. Folia rosulam compactam formantia, membranacea, elliptica vel obovata vel nunc spathulata, ad 2·5 cm. longa petiolo incluso, ad 5 mm. lata, apice obtusa vel rotundata, basi sensim angustata in petiolum alatum laminam subaequantem, margine serratula, supra glandulis farinosis conspersa, infra farina flava dense induta, nervis 4–5-paribus nunc fere occultis. Flores 1–2-nati; scapus primo inter folia tectus, tandem ad 2·5 cm. altus, apice flavo-farinosus; bracteae lineares, ad 5 mm. longae, farinosae; pedicelli 2–3 mm. longi. Calyx viridis, extra farina conspersus, intra dense indutus, 6–8 mm. longus, nervis quinque conspicuis, in lobos lanceolatos vel oblongo-lanceolatos obtusos vel nunc obscure tridentatos ad medium vel paulo ultro fissus. Corolla lilacina vel pallido-purpurea vel nunc vinoso-rubra; tubus calycem aequans vel paululo longior, extra pallido-lilacinus, intra atque ad fauces farina farctus, oculum flavum simulans; limbus ad 2 cm. diametro; lobi late obcordati.

7 mm. longi et lati, alte emarginati. Stamina in floribus brevistylis prope fauces inserta, in fl. longistylis ad medium tubum. Stylus in fl. longistylis tubum vix aequans, in fl. brevistylis ad medium tubum attingens. Capsula calyce paulo longior, valvulis apicalibus dehiscens.

"S.E. TIBET. On the Lo La, Pachakshiri. Lat. N. 28° 46′. Long. E. 94° 00′. Alt. 11,000 feet. Corolla dark lilac to lilac, turning to darker in the centre. Inside of tube and throat thickly covered with a yellowish farina, giving the appearance of a yellow eye. Outside of the tube palest lilac. Calyx green, the lobes slightly darker. Calyx and scape lightly covered with farina. Back of leaves densely covered. About equally divided between 1 and 2 flowered plants. Growing up through old leaves in wet moss on inaccessible sheer cliff face. 24.4.38." *Ludlow, Sherriff and Taylor*, No. 3640. Type in Herb. Brit. Mus. Same locality, No. 3756.

"On the Chubumbu La (S. side). Lat. N. 28° 47′. Long. E. 93° 44′. Alt. 13,000–14,000 feet. Corolla mauve, lilac, or sometimes rich wine-red, deepening in the centre. Tube pale wine-red. Thick yellow farina inside tube which also shows in the eye. Calyx dull green. Calyx, bracts, scape, and leaves farinaceous. Back of leaves thickly covered. Common on sheer cliff faces, in moss. 7.6.38." *Ludlow, Sherriff and Taylor*, No. 3987.

A very elegant dwarf species which recalls in habit and flower such members of the section Minutissimae as *P. tenella* King and *P. flagellaris* W. W. Sm. Its nearest kin is probably *P. rhodochroa* W. W. Sm. which has smaller flowers and white farina. The specific name is in honour of the Lady Colquhoun of Rossdhu.

Primula praetermissa W. W. Sm. Spec. nov.

Species perpusilla ex affinitate *P. subulariae* W. W. Sm. in sectione Minutissimis a qua foliis plus minusve lanceolatis, calyce late cupulari, ore corollino albo-pilosulo inter alia divergit.

Planta pygmaea 1·5 cm. vix superans, omnino efarinosa. Folia ad 10 mm. longa, 2 mm. lata; lamina oblanceolata vel spathulata, apice obtusa, basi in petiolum vix discretum brevem alatum sensim angustata, integra vel nunc dentibus 1–3 distantibus obtusis praedita, glabra, nunc glandulis paucis sessilibus infra munita, nervis obscuris, costa ipsa tantum infra prominula. Scapus brevissimus, ad 3 mm. attingens, uniflorus; bracteae lineares 0·5 mm. longae, sub calyce 1 mm. insertae. Calyx cupularis, ad 2 mm. longus, in lobos triangulares obtusos ad medium fissus. Corolla coeruleo-purpurea, monomorphica; tubus cylindricus, calycem fere triplo superans; limbus 5 mm. diametro; lobi oblongi, 2 mm. longi, 1 mm. lati, alte emarginati; os corollinum pilis albidis laxe impletum. Stamina paulo supra medium tubum inserta. Stylus stamina aequans vel paulo excedens. Ovarium 1 mm. diametro. Fructus deest.

S.E. TIBET. Details of exact locality not yet available. *Ludlow, Sherriff and Taylor*, No. 5196A. Found along with No. 5196, which is *P. Genestieriana* Hand.-Mzt.

Comparable among the Minutissimae only to *P. subularia* W. W. Sm., and like that species is efarinose and glabrous.

Primula rimicola W. W. Sm. Spec. nov.

Species tibetica ex affinitate *P. tenellae* King a qua foliis oblanceolatis vel spathulatis, fere ex toto denticulatis, farina flavida nec alba, petiolis brevioribus, calyce ad tres partes vel nunc fere ad basim fisso, lobis acutis, ore corollino intra glabro distinguitur; a *P. spathulifolia* Craib autem affini foliis calyceque longius removitur.

Planta pusilla, rhizomate brevi crassiusculo, foliis annotinis emarcidis basi persistentibus. Folia numerosa rosulam densam formantia, in sicco membranacea, oblanceolata vel spathulata, ad 3 cm. longa petiolo incluso, ad 7 mm. lata, apice rotundata, basi in petiolum membranaceo-alatum laminam subaequantem sensim angustata, margine subirregulariter denticulata, supra interdum sparsim farinosa, subtus farina flava copiose induta, costa lata atque infra conspicua, nervis 5–6-paribus subtus manifestis sed saepe fere farina occultis. Flos solitarius; scapus primo brevissimus foliis fere tectus, tandem 2–2·5 cm. altus, flavido-farinosus; bracteae 2–3, lanceolatae vel lineari-lanceolatae, 2·5 mm. longae, farinosae; pedicelli 2–3 mm. longi. Calyx viridis, membranaceus, 6–7 mm. longus, extra farina conspersus, intra farctus, in lobos lanceolatos acutos pilis farinipotentibus ciliatos ad tres partes fissus. Corolla pallido-purpurea, oculo albo vel flavido; tubus cylindricus, apice paulo dilatatus, calycem duplo superans; limbus 1·5–2 cm. diametro; lobi patentes, obcordati, 7 mm. longi et lati, alte emarginati. Stamina in floribus longistylis prope ad basim tubi corollini inserta. Stylus calycem paulo superans. Capsula deest.

"S. TIBET. Kashong La, Chayul Chu. Alt. 15,000 feet. Corolla slightly purplish pink, eye white to slightly yellow. Leaves, under surface white with farina. Upper surface, scape, and calyx also mealy. In sheltered crevices in cliffs. South of main range. Flowers mostly over. 14.7.36." *Ludlow and Sherriff*, No. 2359 (*type*).

Like *P. tenella* King, this new member of the section Minutissimae has solitary flowers, but its general aspect indicates a certain relationship with the large section Farinosae. Its leaf and calyx characters separate it easily from *P. tenella*, which appears to be its nearest ally. The farina which coats the under surface of the leaves is in the dried state of a pale yellow hue rather than white.

Primula Sharmae H. R. FLETCHER. Spec. nov.

Species proxima *P. Schlagintweitianae* Pax a qua foliis subtus dense flavido-farinosis, calyce majore intra farina impleto, corollis majoribus, tubo valde elongato calycem duplo vel nunc triplo superante inter alia divergit.

Planta ad 10 cm. alta, rhizomate brevi crasso, foliis emarcidis anni prioris plus minusve persistentibus. Folia membranacea, ad 6 cm. longa petiolo incluso, ad 1 cm. lata, spathulata vel oblongo-elliptica, apice acuta vel obtusa vel nunc subrotundata, basi sensim attenuata in petiolum membranaceo-alatum brevem vel saepe partem laminae tertiam aequantem, margine denticulata vel interdum subintegra, supra atroviridia glabra, infra farina flava dense praedita, costa lata conspicua, nervis 5–6-paribus vulgo farina occultis. Scapus ad 10 cm. altus, satis firmus, apice farinosus, umbellam ad 8-floram gerens. Bracteae lineari-lanceolatae, basi latiusculae atque interdum minime saccatae, ad 8 mm. longae, valde carinatae, extra leviter farinosae, intra copiose; pedicelli ad 7 mm. longi, farinosi. Calyx 5–10 mm. longus, extra farina conspersus, intus farctus, 5-costatus, in lobos lanceolatos vel oblongos apice acutos vel nunc fere rotundatos margine glandulo-ciliatos fere ad duas partes divisus. Corolla ex collectore coerulea sed in sicco potius purpurea esse videtur; tubus anguste cylindricus, calycem duplo vel nunc fere triplo superans, in floribus longistylis supra a medio ampliatus, in floribus brevistylis tantum apud fauces dilatatus; limbus 1·5–2 cm. diametro, circum os paulo farinosus; lobi patentes, late obcordati, 5–7 mm. longi et lati, alte emarginati. Stamina in fl. brevi. paulo infra os inserta, in fl. longi. ad medium tubum. Stylus in fl. longi. calycem $1\frac{1}{2}$–2-plo superans, in fl. brevi. calycem aequans. Capsula calycis longitudine, apice dehiscens valvulis tandem ad basim pertinentibus.

NEPAL. Muktinath: Alt. 13,500 feet. Flowers blue. 20.7.31. *K. N. Sharma*, No. E. 272 (*type*). Alt. 15,000 feet. 15.7.31. *K. N. Sharma*, No. E. 24. Alt. 15,000 feet. 16.7.31. *K. N. Sharma*, No. E. 29. Baituk: Alt. 13,000 feet. Flowers blue. 8.7.32. *K. N. Sharma*, No. E. 344.

This Nepal species finds its nearest ally in *P. Schlagintweitiana* Pax of the Western Himalaya. In general appearance both are clearly associated with *P. farinosa* Linn., but this widespread species has not been found in the Himalayan Range. In both cases the very elongate corolla-tube serves as one distinction from *P. farinosa*. The specimens quoted were obtained by the late Professor K. N. Sharma, who made botanical collections for H.R.H. The Maharaja of Nepal.

P. stenodonta Balf. f. MS. descript. W. W. Sm. et Fletcher.

Species affinis *P. Poissonii* Franch. atque *P. Wilsoni* Dunn a quibus bracteis multo longioribus calycisque lobis angustis longe acuminatis divergit; autem haud procul a *P. Beesiana* Forrest a qua inflorescentia omnino efarinosa inter alia removitur.

Folia oblonga vel oblanceolata vel nunc obovata, ad 15 cm. longa, ad 4 cm. lata, apice rotundata, basi in petiolum brevem late alatum sensim attenuata, margine regulariter denticulata, utrinque glabra, infra glandulis farini-potentibus conspersa. Scapus omnino efarinosus, ad 30 cm. altus, umbellas 2–3 superpositas floribus rubro-violaceis gerens; pedicelli ad 1·5 cm. longi; bracteae lineares plus minusve pedicellos aequantes. Calyx tubuloso-campanulatus, 5–6 mm. longus, in dentes lanceolatos longe acuminatos ad medium fissus. Corollae tubus calyce duplo vel triplo longior, ore distincte annulatus; limbus plus minusve patens, ad 1·5 cm. diametro.

Stamina in floribus brevistylis paulo infra annulum inserta; Stylus calycem aequans vel nunc paulo longior. Capsula non visa.

N.E. YUNNAN. Ou-tchai, near to Ta-kouan (*Delavay*, 214 bis—*type* in Herb. Edinburgh; *Delavay*, 314 bis). At Tse-tchou-pa and at Tsang-fang (*Maire*).

Further details concerning this species are given on page 176.

THE GENUS PRIMULA: SECTION CANDELABRA, Balf. fil.

By W. WRIGHT SMITH and H. R. FLETCHER.

(Read 23rd October 1941.)

The name Candelabra was proposed by Balfour in his paper read at the Primula Conference in April 1913. In that paper he points out that the section corresponds in part to Pax's section Cankrienia as given in Pax's monograph of the genus Primula in Engler's Pflanzenreich, published in 1905. Much earlier, however, in 1889, in Engler's Bot. Jahrbuch, x, p. 217, Pax had constituted the section Proliferae, but in the monograph this name was suppressed by him in favour of Cankrienia. Both these previous sections were somewhat vitiated by unnatural groupings and contained species in no way closely related. In the original section Proliferae we find four species —*P. prolifera* Wall., *P. japonica* A. Gray, *P. serratifolia* Fr., and *P. Poissonii* Fr.—which are now regarded as coming within the section Candelabra. Pax, however, added *P. Maximowiczii* Regel, which is a Nivalid, *P. membranifolia* Fr., which belongs to the Farinosae, *P. Parryi* A. Gray, which now falls into a section of that name, and *P. sonchifolia* Fr., which is a Petiolarid. Later, it is true, Pax removed *P. Maximowiczii* to his section Nivales, and correctly so. He also saw reason to remove *P. membranifolia* to a somewhat heterogeneous section, Callianthae. However, in 1905, when he came to rename his section he still retained within it such species as *P. Parryi*, *P. sonchifolia*, *P. Rusbyi*, and *P. breviscapa*—all now referred to other sections. Of the seven apparently legitimate species then left in his section, three are chimaeras. The material quoted by Pax as representing *P. prolifera* embraces also the distinct species *P. Smithiana*; *P. serratifolia* as enumerated by Pax contains not only that species but also *P. pulverulenta* Duthie; while his *P. angustidens* is in part *P. Wilsoni* and another species which will be found now under the name of *P. stenodonta*. In view of this confusion, no doubt due in great measure to the imperfect material at that time available to the monographer, it seems to us that Balfour was justified in finding a new name, and the one chosen appeared to be particularly appropriate. At a much earlier date Sir

Joseph Hooker, when discussing *P. imperialis* in 1892 in the Botanical Magazine, under tab. 7217, speaks of that species along with *P. japonica*, *P. prolifera*, and *P. Poissonii* as the "Imperial Primroses." Such an appellation would also have been eminently suitable. The species quoted by Balfour in the paper referred to at the Primula Conference in 1913 are all clearly associated and form a homogeneous group. In the subsequent years, 1913–22, Balfour included in his working list the following: *P. anisodora* Balf. f. et Forrest, *P. burmanica* Balf. f. et Ward, *P. chrysochlora* Balf. f. et Ward, *P. Cooperi* Balf. f., *P. chungensis* Balf. f. et Ward, *P. ianthina* Balf. f. et Cave, *P. khasiana* Balf. f. et W. W. Sm., *P. leucantha* Balf. f. et Forrest, *P. Miyabeana* Ito et Kawakami, *P. oblanceolata* Balf. f., *P. prenantha* Balf. f. et W. W. Sm., *P. stenodonta* Balf. f. MS. In recent years a few other species of the section have come to light: *P. aurantiaca* W. W. Sm. et Forrest, *P. melanodonta* W. W. Sm., *P. microloma* Hand.-Mzt., *P. Morsheadiana* Ward. At the Primula Conference of 1928 Smith and Forrest recorded all the known species of the section at that date. Since then the only species which falls to be added is *P. polonensis* Ward. It will be seen from the 1928 record that four of the names there quoted are put simply as synonyms, and the present authors do not dissent from the view there taken.

The Edinburgh herbarium is fortunate enough to possess material of all the species—in some cases very complete and for the great majority containing either the types or co-types. The present survey would appear to confirm that no heterogeneous element is present in the section. It is not always easy to draw a definite line between some of the sections of Primula, but Candelabra seems to be a very natural and distinct series and shows no very close association with any other section, nor does it appear to contain any doubtful members tending in the direction of other sections. In a general way the foliage recalls the familiar features of the section Vernales to which belong the common Primroses of Europe. The section Vernales, however, is completely efarinose, while the majority of the species in section Candelabra show a certain amount of farina on the inflorescence. The name indicates the general appearance of the inflorescence where there is usually a number of superposed umbels. It has to be remembered, however, that a similar inflorescence is found in other sections, while some of the less robust members of the section Candelabra frequently show but a simple umbel. Diagnostic also is the character of the fruit which in the great majority of cases is completely rounded or globose, and the only deviation from this character is found in *P. Cockburniana* and in *P. Poissonii* and its immediate allies, where the fruit is somewhat more elongated and could be termed very shortly oblong.

The distribution of the section is confined entirely to Asia, and the chief centre is undoubtedly in the alpine regions of the south-west of China, particularly in the provinces of Yunnan and Szechuan. Its excursions from this centre are somewhat limited. Some of the species extend beyond the Chinese boundaries into alpine Burma and S.E. Tibet; one species is found in Java; it does not extend very far into the Himalaya, nor is it strongly represented there in species; its most westerly extension in this direction would appear to be *P. ianthina* from West Sikkim, and not far from that locus is found *P. Cooperi* in the centre of Sikkim. One species is found in Japan and one in Formosa.

As already indicated, we regard the section as somewhat isolated and showing no definite transitions into any other section. In this connection, however, it is fitting to consider the cytological evidence. This has been investigated very fully by Bruun in his "Cytological Studies in Primula" in the year 1932. Bruun examined some nineteen species of the section and found that with two exceptions they all showed remarkable conformity as to the number, size, shape, etc., of the chromosomes. All with one exception have the basic number eleven in their chromosomes. The one exception is *P. japonica*, which is the only tetraploid in the section. It will be noted that this species is one of the farthest removed from the centre of the section. Bruun indicates that *P. ianthina* is separated from the others by its distinctly non-uniform chromosomes, and here again we have another outlier, this time on the western side. The other two outliers, *P. Miyabeana* and *P. imperialis*, show no marked deviation from the general members of the section. Bruun concludes that the most closely related cytological type is the section Nivales. The ordinary morphological characters of this section do not strongly support this conclusion, for the distinctions between the two sections are very evident. Granted, however, that cytologically this is the *nearest* section, then further warrant is given to the view that the section Candelabra is not closely linked with any other section of the genus.

The introduction of members of the section into cultivation in Europe is of comparatively recent occurrence and has taken place almost entirely within the present century. In so far as the cultivation of the genus Primula is concerned this section has already attained a dominant position. One can affirm that more members of the section, and these in greater numbers, are grown now in European gardens than of any other section of the genus. This is not entirely due to appreciation of the fine quality of many of the species for garden purposes. They have shown themselves very tolerant of general European conditions, and, unlike members of many of the sections, usually produce abundant seed. These characters will certainly serve to keep this section in the forefront they have rapidly attained.

The species are all perennial, and most are robust plants with a tuft of spreading leaves after the style of the common primrose (*P. Poissonii* and its allies are an exception to this) from which arise tall scapes bearing superposed whorls of flowers. There is a short thick rhizome, quite free from the desiccated remains of the old leaf bases, except at the crown where, among soft leaf remnants, axillary renewal buds are formed. These buds develop freely and build up a multicipital sympodial axis. This organisation may well be correlated with the general habitat of the species—marshes, by stream courses, or in damp soil, so that the roots have a free run amongst moisture. Though all the Candelabras are perennial, some, *P. Cockburniana* Hemsl. for example, are frequently short lived and are sometimes spoken of as biennial. It may be that their free seeding is an important factor in bringing about shortness of life, causing a contest with the crown axillary buds for the available food and thus retarding their development. The usual method of growth is as follows. The scape is terminal and perennation is brought about by the renewal buds in the axils of the leaves around it. In early spring species such as *P. Beesiana*, *P. Bulleyana*, and *P. japonica* have several renewal buds upon the rhizome. Later on, each of these buds may grow out forming foliage leaves and ending in the bud of a flower scape. As this takes place, several of the axillary renewal buds also start growth and produce leaves which may reach a considerable size by the time flowering of the main axis occurs. In this way arises the tufted habit of these plants—many rosettes of leaves seem to cluster around the flower axis. During the summer and autumn the fruits ripen, the scape rots off at its base, and the vegetative activity of the plant now centres in these lateral renewal buds which have produced roots and large leaves so characteristic of the autumn. With the winter, these large leaves begin to rot off at the base, to leave only a cluster of unexpanded foliage leaves which envelop the growing point of the axis as the resting stage during the winter. In the following spring these resting buds once again start new growth.

But not all the species behave thus. *P. Poissonii* and its allies in the winter do not lose all their leaves. The renewal buds retain some of the leaves formed during the summer and the autumn, and thus the plant perennates with a number of green rosettes. Again, *P. Cockburniana* differs from all the other species in having a very small rhizome and buds covered with scales. With the ripening of the fruit in the autumn, the leaves of the basal rosette rot to their base and expose the axillary renewal buds, which, deprived thus early of the axillary leaf base protection, are enclosed in small thick fleshy scale leaves, the outermost of which become green. The buds are more or less globose and are arranged in a circle around the base of the drying scape, and have already rooted while still attached to the parent plant. By these fleshy bud scales *P. Cockburniana* may be propagated in the same way as a lily.

The species are readily separable into two main groups by their flower colour; one group with red or purple flowers, the other with yellow or orange flowers. Within the groups the species can be arranged according to the presence or absence of farina.* Farina on the foliage is not a character of these primulas, for in only one species, *P. Cockburniana*, is there a suspicion of meal, though the potentiality for mealiness would seem to be present in all the species. It is in the scape and the parts of the flower that farina offers important diagnostic characters. Sometimes the scape is efarinose; sometimes markedly farinose, especially in the nodal areas; sometimes the farina spreads on to the bracts, the pedicels, and the calyx; sometimes only the interior of the calyx shows farina: and some species are completely efarinose. The scape is usually stout and bears in well-developed plants one or more tiers of flowers below the terminal umbel. Only occasionally does a species bear but a single umbel. The flowers, up to 20 in a whorl, are always stalked and are nodding, horizontal or ascending. In fruit the pedicels are more or less erect and in some species, *P. Poissonii* for instance, may be adpressed to the scape. The bracts may be either shorter or longer than the pedicels; usually they are of lanceolate character, though in some species they may be broadly ovate and foliaceous at the apex. The calyx, which is campanulate or tubular-campanulate, has always five sepaline ribs, and lobes which generally are more or less equal in length to the tube (though occasionally, as in *P. mallophylla*, they may be very much longer) and which terminate in a hydathode.

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* In some other sections the presence or absence of farina and its degree may be a fluctuating character, and of doubtful value for diagnosis, but in Candelabra its incidence appears to be particularly stable and thus of value in discrimination.

The corolla is usually markedly annulate. Usually the lobes are patent so that the limb is flat, but in some species, *P. Wilsoni*, *P. anisodora*, and *P. prenantha*, the lobes are not bent back at right angles to the tube, so that the limb is concave. The other important diagnostic character in connection with the corolla is that it may be either monomorphic or dimorphic—that is to say, the stamens may be inserted in the corolla tube so that they are at the same level as the stigma, or they may be inserted so that they are at a different level to the stigma, giving two types of flower as in the common primrose. *P. Smithiana*, *P. helodoxa*, *P. aurantiaca*, *P. burmanica*, and *P. serratifolia* all have dimorphic or heterostyled flowers, whilst *P. japonica*, *P. Cockburniana*, *P. imperialis*, and *P. prenantha* have monomorphic or homostyled flowers. *P. chungensis* is outstanding in that the flowers exhibit both conditions.

Apart from *P. Poissonii* and its allies, the capsule is either globose or shortly ovoid and is more or less enclosed by the calyx, the lobes of which commonly lie adpressed to the summit of the capsule. In *P. Poissonii*, *P. Wilsoni*, and *P. anisodora*, on the other hand, the capsule is shortly cylindrical and projects some little distance beyond the calyx. Very often the apex of the capsule is thickened, and the thickening can be seen even in the young ovary and takes the form of a crowning cap or lid around the base of the style. Both in the ovary and in the capsule this lid shows five grooves which radiate outwards from the base of the style. Sometimes the five-grooved lid is coloured and, as in *P. Poissonii*, forms a convex reddish cover at the apex of the capsule. The whole construction is that of a typical stylopod. Within the capsule, the placenta has a short basal stalk, and the apex continues as a thin thread into the canal of the superlying style. In most cases dehiscence begins by the formation of a circular slit in the stylopod within its outer margin. The central disc-like portion of the stylopod, with the style fixed in the centre, may fall off lid-like, and thus leave an apical hole in the capsule, or it may remain and hold on to the placenta by the thread-like placental projection in the canal of the style. Thereafter, the wall of the capsule may split more or less regularly by slightly recurving valves, the tops of the valves being the outer portion of the thickened covering cap of the capsule. Sometimes there are five valves, sometimes ten, or there may be an uncertain number. At times, however, the splitting of the capsule may be quite irregular. Again the stylopod may split along its five radiating grooves, without any preliminary circumscissile dehiscence, and thus the capsule appears to dehisce by five apical recurving valves. When this happens, as in *P. Poissonii*, the persistent style may remain attached to one of the recurving valves, or it may exhibit at the base the same splitting into five as does the stylopod and each recurving valve has a thread of the style attached to it. The stylopod thus forms a sort of cage over the opened mouth of the capsule.

We are informed by Mr. R. E. Cooper, who has made a detailed study of the seeds of the sections of the genus, that the seeds in the Candelabra Primulas are uniform in their irregularly rhomboidal shape and tend to average 1 mm. in diameter, but less so in the dwarfer species such as *P. prenantha*. The surface of the seeds is more or less regularly and deeply pitted-reticulate as in an empty honeycomb. In certain species there is a tendency for these honeycomb cells to be filled with farina—whether identical with the usual external farina is not yet determined. Mr. Cooper further notes that in other sections such as Cortusoides and Petiolares a pitted-reticulate surface occurs which though comparable can be discriminated from what obtains in Candelabra—but the difference is not easily expressed in words. The seeds of the species of Candelabra can, however, be readily distinguished from those of the Nivales and of Sikkimensis.

The section Candelabra has been subjected to a very detailed and very careful analysis by our friend Professor Alfred Ernst of Zürich. He has published two papers which deal particularly with members of this section. These papers are: (1) Stammesgeschichtliche Untersuchungen zum Heterostylieproblem, which appeared in vol. 48 (1938) of "Berichte der Schweizerischen Botanischen Gesellschaft." (2) Zur Kenntnis des Blütenbaues von *Primula imperialis* Junghuhn und *Pr. prolifera* Wallich (1940), published in "Annales du Jardin Botanique de Buitenzorg," vol. 49. Professor Ernst has analysed all the members of the section from herbarium material as well as a large number of species from living material. The measurements made by Professor Ernst are very complete and embrace the following points:—

1. The total length of the calyx.
2. The length of the calyx teeth.
3. The length of the corolla tube.
4. The diameter of the corolla tube.
5. The diameter of the limb.
6. The length of the segments of the limb.
7. The length of the pistil.
8. The distance of the stigma from the margin of the calyx.
9. The distance between stigma and anthers.
10. The distance of the anthers from the base of the pistil.

The results of this detailed analysis are very illuminating, but are too comprehensive to be included in this short introduction. Mention, however, must be made of the seven groups into which Professor Ernst has divided the section in accordance with the flower construction. This division coincides to a high degree with what may be regarded as the true phyletic association of the members of the section. As the conclusions may well be of service for diagnosis of the species in addition to the analytical key which follows, we are here giving an outline of his seven groups with the floral characters which serve to separate them. They are as follows:—

Group A.—Dimorphic species, with the stigma of the pin-eyed flowers and the anthers of the thrum-eyed flowers at a level with the limb, with the distance between stigma and anthers *less* than half the length of the pistil in pin-eyed flowers, consequently not a marked difference in the length of the pistils and in the position of the anthers for both types of flower.

1. P. Beesiana *G. Forrest.*
   subspec. P. leucantha *Balf. f. et Forrest.*
2. P. burmanica *Balf. f. et Ward.*
3. P. aurantiaca *W. W. Smith et Forrest.*
4. P. Bulleyana *G. Forrest.*
5. P. pulverulenta *Duthie.*
6. P. serratifolia *Franch.*
7. P. mallophylla *Balf. f.*

Group B.—Dimorphic species, with the pistil of the pin-eyed flowers and the anthers of the thrum-eyed flowers at a level with the corolla limb, the distance between the stigma and anthers *greater* than half the length of the pistil of the pin-eyed flowers, with therefore a marked difference in the length of the pistil and in the position of the anthers for the two types of flower.

8. P. Smithiana *Craib.*
9. P. helodoxa *Balf. f.*
   subspec. P. chrysochlora *Balf. f. et Ward.*

Group C.—Monomorphic and monomorphic-dimorphic species of the central distribution zone (Yunnan-Szechuan), stigma and anthers of uniform length at the level of the corolla limb.

10. P. Cockburniana *Hemsl.*
11. P. chungensis *Balf. f. et Ward.*

Group D.—Monomorphic species of the Malayan-Japanese distribution region of the section, stigma and anthers of uniform length at the level of the corolla limb.

12. P. japonica *A. Gray.*
13. P. Miyabeana *Ito et Kawakami.*
14. P. imperialis *Jungh.*

Group E.—Dimorphic species, with the stigma of the pin-eyed flowers and the anthers of the thrum-eyed flowers sunk in the upper third of the corolla tube instead of on a level with the corolla limb.

15. P. Poissonii *Franch.*
    subspec. P. angustidens (*Franch.*) *Pax.*
    subspec. P. Wilsoni *Dunn.*
      P. glycyosma Petitm.
      P. oblanceolata Balf. f.
16. P. anisodora *Balf. f. et Forrest.*

Group F.—Dimorphic species, for the most part natives of the western area of distribution of the section (Burma to E. Himalaya), stigma of the pin-eyed flowers and anthers of the thrum-eyed flowers situated above the middle of the corolla tube, anthers of the pin-eyed flowers and stigma of the thrum-eyed flowers situated below the middle of the corolla tube.

17. P. melanodonta *W. W. Smith.*
18. P. ianthina *Balf. f. et Cave.*
19. P. prolifera *Wall.*
20. P. khasiana *Balf. f. et W. W. Smith.*
21. P. Cooperi *Balf. f.*

Group G.—Monomorphic species, for the most part natives of the western part of the distribution area of the section (Burma to E. Himalaya), stigma and anthers situated at the same depth very near the middle of the corolla tube.

22. P. prenantha *Balf. f. et W. W. Smith.*
23. P. brachystoma *W. W. Smith.*
24. P. microloma *Handel-Mazzetti.*
25. P. Morsheadiana *Ward.*
26. P. polonensis *Ward.*

As far as our present knowledge goes the species in this section are as follows:—

P. anisodora *Balf. f. et Forrest.*
P. aurantiaca *W. W. Sm. et Forrest.*
P. Beesiana *Forrest.*
    var. leucantha (*Balf. f. et Forrest*).
P. brachystoma *W. W. Sm.*
P. Bulleyana *Forrest.*
P. burmanica *Balf. f. et Ward.*
P. chrysochlora *Balf. f. et Ward.*
P. chungensis *Balf. f. et Ward.*
P. Cockburniana *Hemsl.*
    P. operculata R. Knuth.
P. Cooperi *Balf. f.*
P. helodoxa *Balf. f.*
P. ianthina *Balf. f. et Cave.*
P. imperialis *Jungh.*
    var. gracilis *Pax.*
P. japonica *A. Gray.*
P. khasiana *Balf. f. et W. W. Sm.*
P. mallophylla *Balf. f.*
P. melanodonta *W. W. Sm.*
P. microloma *Hand.-Mzt.*
P. Miyabeana *Ito et Kawakami.*
P. Morsheadiana *Ward.*
P. Poissonii *Franch.*
    P. planiflora Hand.-Mzt.
P. polonensis *Ward.*
P. prenantha *Balf. f. et W. W. Sm.*
P. prolifera *Wall.*
P. pulverulenta *Duthie.*
P. serratifolia *Franch.*
    P. biserrata Forrest.
        var. roseo-tincta *Forrest.*
        var. unicolor *Forrest.*
P. Smithiana *Craib.*
P. stenodonta *Balf. f.*
    P. *japonica* A. Gray var. *angustidens* Franch.
P. Wilsoni *Dunn.*
    P. angustidens Pax.
    P. glycyosma Petitm.
    P. oblanceolata Balf. f.

Here follows a key to the species of the section. The arrangement of the species in this key is not a phyletic one and is solely for the purpose of identification. Immediately after the key and in alphabetical sequence is given a description of each species with citation of relevant literature and with references to illustrative specimens in the Edinburgh herbarium. As at this date facilities for printing are restricted, it is hoped that these descriptions are reasonably adequate.

KEY TO THE SPECIES.

A. Flowers red or purple, or, in the case of *P. Beesiana* var. *leucantha*, white:—

B. Plants with farina, sometimes only on the inside of the calyx, at the other times on the outside of the calyx, on the pedicels, and on the scape; capsule globose:—

C. Farina present only on the inside of the calyx lobes:—

D. Corolla tube gradually ampliate from the base; calyx at most 6 mm. long, calyx lobes triangular and shortly acuminate; farina sulphur-coloured; corolla lobes mucronulate, crenate-serrate . . . . . . MIYABEANA

DD. Corolla tube cylindrical, ampliate only towards the apex; calyx 8–10 mm. long; calyx lobes triangular and long-subulate; farina white; corolla lobes non-mucronulate, not crenate-serrate:—

E. Flowers monomorphic; leaves obovate-oblong to spathulate; calyx lobes at most twice as long as broad; corolla tube three times as long as the calyx . . . JAPONICA

EE. Flowers dimorphic; leaves oblanceolate; calyx lobes at least twice as long as broad; corolla tube twice as long as the calyx . . BURMANICA

CC. Farina present not only on the inside of the calyx lobes, but also on the outside of the lobes and often on the pedicels and the nodes of the scape:—

D. Farina sulphur-coloured; plant Himalayan . . . . IANTHINA

DD. Farina white; plants Chinese:—

E. Flowers white . . . . . BEESIANA var. LEUCANTHA

EE. Flowers red or purple:—

F. Leaves ovate-lanceolate, broadest at or near the middle; corolla with yellow eye and yellowish tube; calyx lobes lanceolate, equalling or longer than the calyx tube . . . . . . BEESIANA

FF. Leaves obovate to oblanceolate, broadest near the apex; corolla with red or purple eye and red or purple tube; calyx lobes triangular, equalling or shorter than the calyx tube . . . . PULVERULENTA

BB. Plants completely efarinose; capsules shortly oblong (unknown in *P. stenodonta*):—

C. Calyx lobes lanceolate, long-acuminate; bracts as long as the pedicels . . STENODONTA

CC. Calyx lobes triangular; bracts shorter than the pedicels:—

D. Corolla lobes patent, so that the limb is flat; limb 2–3 cm. in diameter; lobes of limb emarginate; capsule as long as or only slightly longer than the calyx; plant non-aromatic. POISSONII

DD. Corolla lobes not patent, so that the limb is concave; limb at most 1·5 cm. in diameter; lobes of limb scarcely emarginate though occasionally with a very slight notch; capsule decidedly longer than the calyx; plant aromatic:—

E. Corolla pale purple to red, eye yellowish; corolla lobes usually sub-rotund, slightly longer than broad; annulus very distinctly 10-lobed . . . . . . WILSONI

EE. Corolla deep blackish-purple, eye greenish; corolla lobes usually sub-quadrangular, slightly broader than long; annulus very indistinctly lobed . . . . . ANISODORA

AA. Flowers yellow or orange, or, in the case of *P. microloma*, white:—

B. Plants with farina on scape, pedicels and calyx:—

C. Calyx segments awl-shaped; midrib of leaf red . . . . BULLEYANA

CC. Calyx segments triangular:—

D. Bracts broadly ovate, leaf-like at the apex; flowers monomorphic; farina bright yellow:—

E. Corolla tube twice as long as the calyx . . . . . . IMPERIALIS

EE. Corolla tube as long as the calyx . IMPERIALIS var. GRACILIS

DD. Bracts lanceolate to linear-lanceolate; flowers mono- or dimorphic; farina bright yellow:—

E. Flowers yellow, dimorphic:—

F. Corolla tube twice as long as the calyx; corolla limb usually 1–1·5 cm. in diameter, at most 2 cm. in diameter; calyx teeth never reflexed . . . . SMITHIANA

FF. Corolla tube three times as long as the calyx; corolla limb usually at least 2 cm. in diameter; calyx teeth often reflexed . . . . . HELODOXA

EE. Flowers orange, but often drying a pale purple-lilac, or even with tinges of red; mono- or dimorphic:—

F. Corolla dark orange, tinged with red; tube at most only twice as long as the calyx; lobes oblong-obovate, usually twice as long as broad; leaves strongly tapering at the base, but usually with a distinct petiole, margin regularly denticulate; flowers constantly monomorphic . . COCKBURNIANA

FF. Corolla pale orange; tube usually three times as long as the calyx; lobes broadly obovate, usually as long as broad; leaves strongly tapering at the base, without a distinct petiole, margin irregularly dentate; flowers mono- or dimorphic . . . . . CHUNGENSIS

BB. Plants completely efarinose:—

C. Bracts as long as, or longer than the pedicels; flowers dimorphic:—

D. Scape puberulous . . . . . MALLOPHYLLA

DD. Scape glabrous:—

E. Scape with at most two tiers of flowers; stamens in long-styled flowers near the base of the corolla tube; an Assam plant . KHASIANA

EE. Scape usually with over two tiers of flowers—up to six tiers; Chinese plants:—

F. Petiole and the midrib at the base, scape, calyx, and pedicels tinged with red; flowers deep reddish orange; stamens in long-styled flowers inserted half-way up the corolla tube . . . . . AURANTIACA

FF. Petiole and the midrib, scape, calyx, and pedicels not tinged with red; flowers yellow; stamens in long-styled flowers inserted towards the base of the corolla tube . . . . . CHRYSOCHLORA

CC. Bracts shorter than the pedicels:—

D. Flowers monomorphic:—

E. Flowers white . . . . . MICROLOMA

EE. Flowers yellow:—

F. Leaves acute at the apex . . BRACHYSTOMA

FF. Leaves round at the apex:—

G. Leaves up to 25 cm. long, margin minutely denticulate; calyx 8–10 mm. long; corolla 2 cm. in diameter; corolla lobes round at the apex . POLONENSIS

GG. Leaves up to 12 cm. long, margin erose-denticulate; calyx 5 mm. long; corolla up to 1 cm. in diameter; corolla lobes emarginate at the apex:—

H. Mature corolla limb under 1 cm. in diameter; corolla lobes 2–2·5 mm. long, not patent but in line with the corolla tube, non-mucronulate at the apex; capsule 5 mm. long, longer than the calyx . . . . PRENANTHA

HH. Mature corolla limb 1 cm. in diameter; corolla lobes 5 mm. long and more or less patent, mucronulate at the apex; capsule 7–8 mm. long, as long as the calyx . MORSHEADIANA

DD. Flowers dimorphic:—

E. Corolla bicolorous:—

F. Corolla yellow with an orange eye and an orange stripe down the centre of each petal . . SERRATIFOLIA

FF. Corolla yellow and more or less flushed with rose, especially on the margin of the corolla lobes. SERRATIFOLIA var. ROSEO-TINCTA

EE. Corolla concolorous:—

F. Leaves at least 5 cm. long, usually over 10 cm. long, at least half as long as the scape:—

G. Leaf margin conspicuously dentate; calyx lobes triangular, acuminate; corolla at most twice as long as the calyx:—

H. Petiole at flowering stage very short or almost obsolete; corolla tube twice as long as the calyx . . SERRATIFOLIA var. UNICOLOR

HH. Petiole at flowering stage as long as the lamina; corolla tube only a little longer than the calyx . COOPERI

GG. Leaf margin denticulate; calyx lobes lanceolate; corolla tube at least twice as long as the calyx, up to three times as long . . . . . PROLIFERA

FF. Leaves at most 5 cm. long, margin deeply dentate; scape 3–5 times as long as the leaves . . MELANODONTA

P. anisodora Balf. f. et Forrest in Notes Roy. Bot. Gard. Edin., ix, 147 (1916); W. W. Sm. et Forrest, *ibid.*, xvi, 17 (1928); W. W. Sm. et Forrest in Journ. Roy. Hort. Soc. London, liv, 13, 43 (1929); Hand.-Mzt., *ibid.*, liv, 56 (1929); M'Laren, *ibid.*, liv, 65 (1929); Gould, *ibid.*, liv, 70, 71 (1929); Bot. Mag., t. 8752 (1918); Hand.-Mzt. in Symbolae Sinicae, vii, 749 (1936).

George Forrest found this striking primrose in moist pastures on the Chungtien Plateau in Yunnan at an altitude of 3700 metres in 1913. Seed was collected which, on arrival in this country, germinated and produced flowering plants in 1916. From that time the species has been continually in cultivation. It is undoubtedly a close ally of *P. Wilsoni*, and in the herbarium, unless the colour of the flower is known, the two species are almost impossible to separate. In the garden, however, *P. anisodora* with its deep blackish-purple flowers is very distinct.

From a rosette of glabrous efarinose obovate leaves up to 25 cm. long and 8 cm. broad, obtuse or round at the apex, tapering at the base into the extremely broad-winged petiole and regularly or irregularly denticulate at the margin, arises the stout scape, up to 60 cm. tall. This carries three to five superposed umbels of up to eight or ten flowers, the latter being borne on pedicels 1–1·5 cm. long. The pedicels are half-nodding in flower and erect in fruit, and arise from the axils of linear to linear-lanceolate bracts up to 1·5 cm. long. Cup-shaped and up to 5 mm. long, the calyx is lobed for a third of its length, the lobes being broadly ovate, prominently nerved, obtuse or round at the apex and often hydathode-fimbriate at the margin. The infundibuliform corolla is deep purple, almost black in fact; the tube is up to 1 cm. long and has a deep and unequally 10-lobed annulus at the throat, whilst the concave limb, at most 1·5 cm. in diameter, has the lobes subquadrangular, subtruncate and imbricate, usually at most 3·5 mm. long and 5 mm. broad, crenulate at the margin and sometimes slightly emarginate. In short-styled flowers the stamens, with anthers 1·5 mm. long, are inserted between the middle of the corolla tube and the annulus, whilst the style is barely 2 mm. long. The capsule is decidedly longer than the calyx and dehisces by five valves.

YUNNAN. Mountains of the Chungtien Plateau (*Forrest*, 10617—*type*, 12730, 16466); Chienchuan-Mekong divide (F. 21548, 23414, 23416); Gao-du Shan (F. 20548); Shui-mun-kai (F. 30217); without precise locality (F. 16898, 22579).

SZECHUAN. Mountains of Kulu (*Rock*, 17959); without precise locality (R. 23684, 23686). Mountains near Yalung and Yenguen (*Handel-Mazzetti*, 2581). Near Tatiasko (*Schneider*, 1372).

P. anisodora thrives best in a good moist loam and may even be treated as a bog plant during the growing season. After flowering freely the plant dies but produces abundant seeds.

Pollen from *P. anisodora* has been used for fertilising *P. helodoxa* and the resulting hybrid is known in gardens as *P. anisodoxa.* The original hybrid had dark chocolate flowers with a yellow eye and with traces of orange in the corolla tube and towards the edge of the petals. Plants of the F_2 generation, however, had flowers all shades of magenta with a predominance of red.

P. aurantiaca W. W. Sm. et Forrest in Notes Roy. Bot. Gard. Edin., xiv, 34 (1923); W. W. Sm. et Forrest, *ibid.*, xvi, 17 (1928); Forrest in Journ. Roy. Hort. Soc. London, xlix, 35 (1924); W. W. Sm. et Forrest, *ibid.*, liv, 43 (1929); *ibid.*, liv, 56, 78 (1929); Gard. Chron., Ser. 3, lxxvii, 38 (1925); Hand.-Mzt. in Symbolae Sinicae, vii, 751 (1936).

In July 1922, growing beside streams in moist alpine pasture, at an altitude of 3500 metres, this plant was found by Forrest in flower on the Chienchuan-Mekong divide, and in September of the same year and in the same locality he collected fruiting specimens.

It is an efarinose plant up to 30 cm. tall. The leaves are oblanceolate to obovate, up to 20 cm. long and 5 cm. broad, round at the apex, tapering at the base, usually very strongly so, erose-denticulate at the margin, glabrous on the upper surface and obscurely pulverulent on the lower surface. From the rosette of leaves arise one or two scapes which are up to 30 cm. tall, glabrous, tinged with red, and which carry from two to six whorls of six to twelve flowers. The flowers are supported by linear bracts, pulverulent at the base and up to 15 mm. long, and are carried on reddish pedicels at most 1 cm. long. Narrowly campanulate and about 8 mm. long, the calyx is tinged with dark red without, is green within and is divided to slightly below the middle into narrowly oblong, acute or obtuse lobes. The corolla is deep reddish orange and is faintly annulate; the tube in thrum-eyed flowers is about twice as long as the calyx, and in pin-eyed flowers as long as or slightly longer than the calyx, whilst the limb is 1 cm. broad and has the lobes narrowly obovate or suboblong and slightly emarginate. In thrum-eyed flowers the stamens are inserted slightly below the throat of the corolla, and the style is shorter than the calyx; in pin-eyed flowers the stamens are inserted half-way up the corolla tube, whilst the style reaches the annulus. The capsule is globose and about 5 mm. in diameter.

YUNNAN. Chienchuan-Mekong divide (*Forrest*, 21497—*type*, 21501, 22287, 22318, 23413, 23417); Chao-ii Shan, Mekong-Yangtze divide (F. 25732); Lamping Shan (F. 30293). On Lao-chun Shan, S.W. of Shi-ku and Yangtze (*Rock*, 25086, 25409).

The species was introduced in 1923 by Forrest and has continued in cultivation since that date.

P. Beesiana Forrest in Gard. Chron., Ser. 3, l, 242, fig. 110 (1911); *ibid.*, lxviii, 299 (1920); *ibid.*, lxxxvii, 385 (1930); Journ. Roy. Hort. Soc. London, xxxviii, Proc. cxx (1912); *ibid.*, xxxix, 132, 137, 166, fig. 74 (1913); Forrest, *ibid.*, xli, 206, fig. 75 (1915); Kingdon Ward, *ibid.*, xlviii, 203 (1923); xlix, 152, 153 (1924); li, 87 (1926); liv, 43, 69, 70, fig. 59 (1929); and lviii, 404 (1933); Hand.-Mzt. in Symbolae Sinicae, vii, 751 (1936).

P. Beesiana was first found by Forrest on the Lichiang Range in 1906. At the same time and in the same locality he also found *P. Bulleyana*, and the close affinity of these two plants is discussed under the latter species. *P. Beesiana* is also closely related to *P. pulverulenta*, for both have reddish or purplish flowers and farina on the nodes of the scape, the pedicels, and the calyx. *P. Beesiana*, however, has ovate-lanceolate leaves which are broadest at or near the middle, whilst Duthie's plant has obovate to oblanceolate leaves which are broadest near the apex. In addition Forrest's plant has a yellow eye and a yellowish tube to the corolla and lanceolate calyx lobes, whilst *P. pulverulenta* has a red or purple corolla tube and eye and triangular calyx lobes.

P. Beesiana was introduced into cultivation by Messrs. Bees Ltd. from seeds which were sent home by Forrest in 1908. It has ovate-lanceolate to obovate leaves which are up to 22 cm. long and 6 cm. broad, round at the apex, very markedly attenuate at the base, regularly or irregularly denticulate at the margin and with potentially farinose glands on the lower surface. At fruiting time the leaves may be over 40 cm. in length. The scapes are stout, usually more than one to each plant, and are white farinose at the nodes where the flowers are in whorls. There are from two to eight whorls of flowers with eight to sixteen flowers in the whorl. The linear bracts and the pedicels are of about the same length, from 1–3 cm., and both are efarinose or only faintly farinose. Campanulate, 5–8 mm. long, and usually only slightly farinose on the outside, the calyx is divided to the middle or to just below the middle into lanceolate segments which are heavily coated with farina on the inside. In fruit the calyx segments broaden so that they are more ovate than lanceolate. The tube of the corolla is orange and about twice as long as the calyx, whilst the rose-carmine limb has a yellow eye, is about 2 cm. broad, and has obovate deeply emarginate lobes. In thrum-eyed flowers the stamens are inserted slightly below the mouth of the corolla, whilst the style is half as long as the corolla tube.

YUNNAN. North end of the Lichiang Valley (*Forrest*, 1294—*type*); eastern flank of the Lichiang Range (F. 5977); Lichiang Range (F. 10229, 10268, 10291, 30304); Yungpeh mountains (F. 15359); Yungbu Shan (F. 30264). Between Lichiang and Yungning (*Rock*, 16001); Mountains at foot of Lichiang Snow Range (R. 24947). Near Yungning (*Schneider*, 1614).

SZECHUAN. Mountains around Muli (*Forrest*, 28429, 30271). Mount Gibboh (*Rock*, 24155, 24174, 24579). Near Choso (*Schneider*, 1592).

With *P. Bulleyana* this species has been the progenitor of several interesting hybrids, of which the following are the most important:—

P. X Edina. This hybrid has salmon-coloured flowers and received a Botanical Certificate from the Royal Horticultural Society when exhibited by Sir Isaac Bayley Balfour in 1912.

P. X Asthore. Raised at Lissadell in 1914, seedlings gave a wide range of colour from white to orange to orange-red, pink, and salmon. If *P. Bulleyana* is the seed parent there is a dominance of yellow and orange in the flowers of the offspring. If P. *Beesiana* be the seed parent, then there is a predominance of mauve, rose, and pink shades.

In 1916 an unnamed strain of hybrid Primulas resulting from the crossing of *P. Beesiana* with pollen from *P. Bulleyana* was exhibited by Messrs. Bees at the Royal Horticultural Society and gained an Award of Merit. The flowers varied in colour from salmon to orange, rose magenta, orange-red, and lilac.

P. Beesiana Forrest var. **leucantha** (Balf. f. et Forrest) Fletcher comb. nov. *P. leucantha* Balf. f. et Forrest in Notes Roy. Bot. Gard. Edin., xiii, 12 (1920). *P. Beesiana* subsp. *leucantha* (Balf. f. et Forrest) W. W. Sm. et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 17 (1928), and in Journ. Roy. Hort. Soc. London, liv, 43 (1929).

Collected once by Forrest in the Muli Mountains of S.W. Szechuan, at an altitude of 3 3300 metres, in 1918, this plant, apart from the colour of the flowers, is indistinguishable from *P. Beesiana* which Forrest also found in the Muli Mountains. Though it was originally given specific rank and later subspecific rank it seems best to regard it as a white-flowered variety of *P. Beesiana*.

S.W. Szechuan. Muli Mountains, valley of the Litang (*Forrest*, 16255—*type*).

P. brachystoma W. W. Sm. in Notes Roy. Bot. Gard. Edin., xiv, 35 (1923); W. W. Sm. et Forrest, *ibid.*, xvi, 17 (1928), and in Journ. Roy. Hort. Soc. London, liv, 43 (1929).

Farrer discovered this little-known plant on the Burma-Chinese Frontier, in the region of Shing Hong, in 1920. It was growing at an altitude of 2900 metres in the wet grassy region near a cascade. Undoubtedly a close ally of *P. prenantha* and of *P. Morsheadiana*, the acute apex of the leaf serves readily to separate it from these species.

Farrer's plant is completely glabrous and efarinose. The leaves in the type, which is the only specimen known in herbaria, are oblanceolate to sublanceolate, up to 12 cm. long and 2 cm. broad, acute and shortly apiculate at the apex, very strongly tapering at the base into the short but broadly winged petiole, and regularly denticulate at the margin. The slender scape is up to 20 cm. long and bears a single umbel of two to six flowers which are supported by linear-lanceolate bracts up to 6 mm. long, and carried on pedicels 5–10 mm. long. Campanulate and 5–7 mm. long, the calyx has short more or less triangular teeth about 1 mm. long and apiculate at the apex. Yellow, and with a marked annulus, the monomorphic flowers have a tube 8–10 mm. long and the lobes of the limb are subquadrangular, about 4 mm. long and very shortly emarginate. The stamens are inserted in the middle of the corolla tube and the style reaches to the level of the stamens. Farrer's type is in the Edinburgh Herbarium.

BURMA-CHINESE FRONTIER. In the region of Shing Hong (*Farrer*, 1635—*type*).

P. brachystoma has never been in cultivation.

P. Bulleyana Forrest in Notes Roy. Bot. Gard. Edin., iv, 231, pls. XXXIX A, xlii (1908); W. W. Sm. et Forrest, *ibid.*, xvi, 17 (1928); Gard. Chron., Ser. 3, xlvi, 15, figs. 9, 10, 11 (1909); *ibid.*, lxxiv, 33 (1923); *ibid.*, lxxxvii, 385 (1930); Journ. Roy. Hort. Soc. London, xxxv, 557, Proc. cxxxvi, fig. 88 (1910); *ibid.*, xxxviii, Proc. cxx, cxxi (1913); *ibid.*, xxxix, 132, 166, 167, fig. 77 (1913); *ibid.*, xli, 206, 425, Proc. cxxiii (1915); W. W. Sm. et Forrest, *ibid.*, liv, 43 (1929); Hand.-Mzt., *ibid.*, liv, 55 (1929); McLaren, *ibid.*, liv, 65 (1929); Gould, *ibid.*, liv, 69 (1929); Adamson, *ibid.*, liv, 78 (1929); *ibid.*, lviii, 404 (1933); *ibid.*, lxiv, fig. 44 (1939); Rev. Hort., 467 (1911); *ibid.*, 10 (1916); Journ. Hort., Ser. 3, lxviii, 103 (1914); Tribune Hort., ix, 145 (1914); Bot. Mag., t. 9026 (1924); Hand.-Mzt. in Symbolae Sinicae, vii, 751 (1936).

This handsome plant was discovered by Forrest in 1906 growing in moist mountain meadows on the eastern flank of the Lichiang Range in Yunnan, at an altitude of 2900 to 3200 metres. Forrest was then collecting for Mr. A. K. Bulley of Cheshire, and it was Mr. Bulley who introduced it to cultivation in 1909. In the dried state, when the colour of the flowers may be destroyed, this species can readily be confused with *P. Beesiana* which was also discovered by Forrest in the same year and on the same mountain range, though at the slightly lower altitude of 2600 metres. In some cases the only distinguishing character, and that a very minute one, is that the calyx segments in *P. Bulleyana* are more awl-shaped than those of the other species. In the living state the two species can never be confused, for *P. Bulleyana* has orange-yellow flowers and a red midrib to the leaf, whereas the other plant has rose-carmine or deep red flowers and a lilac or flesh-coloured midrib. Though Forrest found both plants on the Lichiang Snow Range, he maintained that there was no overlapping of the two species. He found both plants growing in the same area (*P. Bulleyana* at a slightly higher level) though never in the same plant association. In the Yungning and Yungpeh mountains, south of the Lichiang, Forrest collected only *P. Beesiana*, though in this locality Rock collected both species. Rock also discovered *P. Beesiana* in South Szechuan, and here also Schneider, according to Stapf in Bot. Mag., t. 9026, discovered *P. Bulleyana*. We have not seen the Schneider specimens referred to by Stapf, but in the Edinburgh Herbarium there are collections of Schneider (S. 1272 and 1403) from Southern Szechuan which have been named *P. Bulleyana*, but which are undoubtedly *P. mallophylla*. Thus, although there may be no common association of the two species, there certainly is an overlapping in the range of each. Moreover, both plants seem to have the same ecological conditions of growth, marsh mountain meadows and the sides of ditches and streams. Though the flower colours have proved more or less stable, except in hybridisation, genetically they may be but definite colour strains of a morphologically uniform unit and then should be treated as colour forms of the one species, *P. Bulleyana*. In the meantime, however, until further experience and experiment confirm this view it is perhaps wiser to regard the two plants as two distinct species.

From the yellow- or orange-flowered, farinose, Candelabra primulas, *P. Bulleyana* is easily distinguished by the red petiole and midrib and the awl-shaped calyx segments. The leaves are ovate to ovate-lanceolate, 12–35 cm. long, 3–10 cm. broad, round at the apex, strongly tapering at the base, irregularly dentate at the margin and with a few potentially farinose glands on the lower surface. The strong scape is up to 70 cm. tall and carries five to seven tiers of flowers. Farina is present at the nodes of the scape, and there is also a thin covering of farina on the linear bracts and the pedicels, both of which are up to 3 cm. long. In fruit the pedicels are almost erect. The calyx is cup-shaped and up to 8 mm. long, is very slightly farinose on the outside and copiously covered with farina within and is lobed to the middle, the lobes being awl-shaped with a very conspicuous midrib. In bud the corolla is a deep crimson and when mature deep orange. The corolla tube is about twice as long as the calyx, whilst the annulate limb is 2 cm. in diameter and has the lobes broadly obovate and emarginate. In thrum-eyed flowers the stamens are inserted towards the top of the corolla tube, so that the anthers, at most 2 mm. long, almost reach the annulus, whilst the style is 4 mm. long. The ovoid capsule is as long as the calyx.

YUNNAN. Mountain meadows on the eastern flank of the Lichiang Range (*Forrest*, 2440—*type*, 2449, 6057, 6150); Lichiang Range (F. 10273, 30248, 30307); Yangtze-Yungning divide (F. 20672). On Yu-lung shan (*Rock*, 25233).

The hybrids between *P. Bulleyana* and *P. Beesiana* are discussed under the latter species.

P. burmanica Balf. f. et Ward in Notes Roy. Bot. Gard. Edin., xiii, 5 (1920); W. W. Sm. et Forrest, *ibid.*, xvi, 17 (1928); Kingdon Ward in Journ. Roy. Hort. Soc. London, xlviii, 203 (1923), and xlix, 152, 153 (1924); W. W. Sm. et Forrest, *ibid.*, liv, 43, fig. 51 (1929); McLaren, *ibid.*, liv, 65 (1929); Kingdon Ward in Gard. Chron., Ser. 3, lxxxviii, 70 (1930).

Kingdon Ward discovered this plant on the Burmese frontier in 1914, growing in low-altitude meadows and in wet forests. It is closely allied to the Yunnan plant *P. Beesiana*, but the two species are readily separated, for *P. burmanica* is completely efarinose except for the inside of the calyx lobes, whereas the other plant has copious farina not only on the inside of the calyx but also on the outside, and on the pedicels and the scape.

The leaves of *P. burmanica* are oblanceolate, up to 30 cm. long and 8 cm. broad, round at the apex, very strongly tapering at the base into the winged petiole, erose-dentate at the margin, glabrous and efarinose on both surfaces, though with a few potentially farinose glands on the lower surface. The stout scape is also efarinose, though it too may have a thin covering of potentially farinose glands, is up to 60 cm. tall, and carries at most six tiers of flowers, there being ten to eighteen flowers in the tier. The pedicels are up to 2 cm. long, and are shorter than the linear-subulate bracts. Glandular-puberulous without and conspicuously white farinose within, the calyx is 1 cm. or more in length and is divided to the middle or to slightly below the middle into five linear-subulate lobes. Reddish purple with a yellow eye, the corolla has the tube usually about twice as long as the calyx and the limb 2 cm. in diameter. The lobes of the latter are obcordate and entire or crenulate-emarginate. The flowers are dimorphic, the style in pin-eyed flowers reaching the mouth of the corolla, whilst the stamens are inserted half-way up the corolla tube.

UPPER BURMA. Below Feng-shui-ling (*Kingdon Ward*, 1634—*type*. *Forrest*, 29689).

YUNNAN. N'Maikha-Salwin divide (*Forrest*, 18043).

P. burmanica does well in cultivation when planted in rich loam and when treated almost as a bog plant. The species seems to have been used in hybridisation only once. In 1931, Mr. P. Gardner of Craven Nurseries, York, exhibited at the Royal Horticultural Society a plant with salmon flowers which was a cross between *P. burmanica* and the hybrid *P. Aileen Aroon*.

P. chrysochlora Balf. f. et Ward in Notes Roy. Bot. Gard. Edin., ix, 155 (1916). *P. helodoxa* Balf. f. subsp. *chrysochlora* (Balf. f. et Ward) W. W. Sm. et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 17 (1928), and in Journ. Roy. Hort. Soc. London, liv, 43 (1929).

This interesting species has, rather remarkably, been collected but once, by Ward, in the Tengyueh marshes of Yunnan. In habit it recalls *P. helodoxa* Balf. f. (a plant which is found in the hills around Tengyueh), but as represented in herbaria by Ward's solitary collection possesses characters which readily distinguish it from this well-known species. Most important of these characters is that the plant is completely efarinose, whereas *P. helodoxa* possesses copious meal on the scape, the pedicels, and the calyx. When Balfour and Ward described *P. chrysochlora* they suggested that it might represent a microform of *P. helodoxa*. This may be the case, but only further collections can prove the truth of this.

P. chrysochlora is completely efarinose and has leaves which are oblong to oblong-obovate, up to 8 cm. long and 3 cm.

broad, obtuse at the apex, tapering at the base into the almost obsolete petiole, irregularly denticulate at the margin and glandular-foveolate on the lower surface. The stout scape is 20 to 40 cm. tall; there is either a single terminal umbel of flowers or three to four superposed umbels, with about twelve flowers in the umbel. Lanceolate and sometimes denticulate, the bracts are up to 2·5 cm. long, whilst the deflexed pedicels are much shorter than the bracts. Up to 7 mm. long, the tubular-campanulate calyx has five conspicuous nerves and triangular teeth which are acuminate and which terminate in a hydathode. The yellow corollas are annulate, the tube twice as long as the calyx and the limb 1 1·5 cm. in diameter. The lobes of the latter are obcordate to subrotundate, up to 8 mm. in diameter, and emarginate. In long-styled flowers the style reaches the annulus and the stamens are inserted towards the base of the corolla; on the other hand, in short-styled flowers the stamens are inserted slightly below the annulus and the style is as long as the calyx. The type specimen is in Edinburgh.

YUNNAN. Marshes near Tengyueh (*Kingdon Ward*, 211—*type*).

P. chungensis Balf. f. et Ward in Notes Roy. Bot. Gard. Edin., xiii, 7 (1920); W. W. Sm. et Forrest, *ibid.*, xvi, 17 (1928), and in Journ. Roy. Hort. Soc. London, xlix, 34 (1924); *ibid.*, lii, 24 (1927); *ibid.*, liv, 43, 65, 71, 78 (1929); *ibid.*, lx, 216 (1935); Kingdon Ward in Gard. Chron., Ser. 3, lxxxviii, 70 (1930).

Ward discovered this plant on the Sha-Ka La in the Chung valley in Yunnan in 1913. The plant was growing in marshes in the forest at an altitude of 2900 to 3200 metres. In subsequent years Ward extended its distribution into Bhutan and to the Assam Frontier, and Forrest and Rock to the Chungtien plateau in Yunnan, and into Szechuan on the mountains N.E. of Muli and Kulu.

P. chungensis has leaves which vary in size from 10–30 cm. long and from 3–10 cm. broad. They are elliptic to oblong to oblong-obovate, round at the apex, cuneate or more often markedly attenuate at the base, obscurely lobulate and irregularly dentate at the margin, glabrous and efarinose, though often with a very thin covering of potentially farinose glands. This species is one of the first, perhaps the first, in the section to flower. It sends up a stout scape up to 80 cm. tall which is markedly farinose at the nodes, and which carries from two to five tiers of flowers with up to twelve flowers to each tier. Lanceolate, strongly keeled and at most 5 mm. long, the bracts are conspicuously farinose, whereas the pedicels, up to 2 cm. long in flower and 3 cm. long in fruit, are only faintly farinose. The campanulate calyx is farinose both within and without, especially so within, is 5 mm. long and is lobed for a little over one-third of its depth, the lobes being triangular and acute. Annulate and pale orange, the corolla has its tube three times as long as the calyx and its limb 1·5–2 cm. in diameter. The lobes of the limb are broadly obovate, usually about as long as broad and are slightly emarginate. The flowers are monomorphic or dimorphic, whilst the globose to ovoid capsule is as long as, or slightly longer than, the calyx.

YUNNAN. Chung Valley, on the Sha-Ka La (*Kingdon Ward*, 259—*type*). Chungtien plateau (*Forrest*, 13857, 30203); Bei Ma Shan, Mekong-Salwin divide (F. 13202). West of Hsiao, Chungtien (*Rock*, 25276). In Tonwa territory, Chungtien (R. 24722).

SZECHUAN. Mountains N.E. of Muli (*Forrest*, 21364). Mount Siga, N.E. of Kulu (*Rock*, 17934); Mountains of Kulu, east of Muli Gomba (R. 16441).

BHUTAN. On the Temo La (*Kingdon Ward*, 5682).

ASSAM FRONTIER. Valley of the Dichu (*Kingdon Ward*, 7107).

P. chungensis gained an Award of Merit from the Royal Horticultural Society in June 1933. It is a plant for the wild garden where it requires sunshine and a damp mixture of mould and sand. When hybridised with *P. pulverulenta* it gave rise to that fine plant *P. chunglenta*, which first flowered in 1929 and which has leaves resembling those of *P. chungensis*, though larger, and flowers like those of *P. pulverulenta*, though they are at first a deep bright red in colour.

P. Cockburniana Hemsl. in Journ. Linn. Soc., xxix, 313 (1893); Pax in Engler's Pflanzenr. Primulaceae, 126 (1905); Journ. Roy. Hort. Soc. London, xxxi, Proc. lxxii (1906); *ibid.*, xxxiii, Proc. li (1908); *ibid.*, xxxix,

> 132, 166, fig. 78 (1913); *ibid.*, li, 87 (1926); *ibid.*, liv, 13, 43, 64, 65, fig. 52 (1929); Gard. Chron., Ser. 3, xxxvii, 332, fig. 137 (1905); *ibid.*, xl, 249 (1906); *ibid.*, lvii, 197 (1915); Bot. Mag., t. 8073 (1906); Jardin, xxi, 21 (1907); Rev. Hort., 179 (1911); W. W. Sm. et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 17 (1928). *P. operculata* R. Knuth in Engler, Bot. Jahrb., xxxviii, 340 (1907).*

Pratt first discovered this plant near Tatsienlu and the type (*Pratt*, 174) is in the Kew Herbarium. Later it was again found by E. H. Wilson to the immediate west of Tatsienlu, in marshy alpine meadows at an altitude of 2900 to 3200 metres. Plants were raised by Messrs. Veitch & Sons, for whom Wilson was collecting, and these were brought to the flowering stage, and the species thus introduced into cultivation in 1905.

Undoubtedly this species and *P. chungensis* are very closely allied. The latter species, however, is usually the more vigorous and taller plant, and has much paler orange flowers which lack the red tint characteristic of the other species. The leaves of *P. Cockburniana* are smaller than those of *P. chungensis*, are more distinctly petioled and have the margin regularly denticulate instead of irregularly dentate.

This well-known biennial has oblong to oblong-obovate leaves up to 15 cm. long and 4 cm. broad, round at the apex, almost round and then suddenly cuneate or else strongly tapering at the base, obscurely lobulate and minutely denticulate at the margin, glabrous and efarinose on both surfaces except for a thin covering of potentially farinose glands on the lower surface. The slender scape is up to 40 cm. tall and carries two or three superposed tiers of flowers, sometimes only one; at the nodes farina is present. Lanceolate and at most 5 mm. long, the bracts are also farinose, as are the pedicels which are up to 3 cm. long. The calyx is campanulate, 5–7 mm. long, farinose both within and without and is lobed almost to the middle, the lobes being triangular to ovate, and acute. The annulate corolla is dark orange, tinged with red; the tube is about 1 cm. long, whilst the limb, with the lobes oblong-obovate and usually twice as long as broad, is 1·5 cm. in diameter. The flowers are constantly monomorphic, the stamens being inserted slightly below the mouth of the corolla tube and the style reaching almost to the annulus. Ovoid or oblong, the capsule is nearly twice the length of the calyx.

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* In 1894, the year after Hemsley had named and described Pratt's specimen, Soulié was collecting near Tatsienlu. He found a primrose, which under the number 2240 was described by R. Knuth in 1907 as *P. operculata*. Knuth's type in the Berlin Herbarium has been examined by Dr. Handel-Mazzetti who says that it is undoubtedly the same plant as *P. Cockburniana*.

S.W. SZECHUAN. On the Djesi-La and Djesi-Longba, south of Tatsienlu (*Rock*, 17583); north of Chiu-Lung-Hsien, in Minya country, south-west of Tatsienlu (R. 17766); Mountains of Yetsi, north of Kulu (R. 23891, 24420). Kang-ting, Tatsienlu (*Harry Smith*, 10674). North of Tatsienlu (*Cunningham*, 168, 444).

P. Cockburniana has been in cultivation since 1905. It requires a moist half-shady, well-drained position in good light loam. With *P. pulverulenta* Duthie it has given rise to several beautiful hybrids which are discussed under Duthie's plant.

P. Cooperi Balf. f. in Notes Roy. Bot. Gard. Edin., ix, 158 (1915); W. W. Sm. et Forrest, *ibid.*, xvi, 17 (1928), and in Journ. Roy. Hort. Soc. London, liv, 43 (1929).

Among the yellow-flowered efarinose Candelabra primulas the nearest relation of this Sikkim plant is the widely distributed *P. serratifolia*. The latter plant, however, has a bicolorous corolla, yellow with an orange eye and an orange stripe down the centre of each petal, whilst Balfour's species is concolorous. *P. Cooperi* has also an unusually short corolla tube, only a little longer than the calyx, whereas the tube of the corolla in the other species is, at least, twice as long as the calyx. Again, at the time of flowering the leaves are very distinctly petioled; on the other hand, the petioles of *P. serratifolia* are very short or sometimes almost obsolete. With the Khasian plant, *P. prolifera*, this Sikkim species also has strong affinity, though *P. prolifera* has the leaves denticulate and not conspicuously dentate, and the corolla tube is up to three times as long as the calyx.

Cooper collected this plant in 1913, above Toong in Sikkim, at an altitude of 3300 metres. The leaves are aromatic and at the time of flowering have longer petioles than any other member of the section, elongate-oblong, up to 18 cm. long and

3·5 cm. broad, acute at the apex, strongly attenuate at the base, and irregularly and conspicuously dentate at the margin. Rising to a height of 30 cm. the efarinose scape carries a single umbel or two superposed umbels of ten flowers. The pedicels are deflexed in flower and upright in fruit and are minutely puberulous, as are the linear-lanceolate bracts which are about 8 mm. long. Tubular-campanulate, markedly five-veined and up to 8 mm. long, the calyx is divided for a third of its length into elongate-triangular, obtuse teeth. The corolla is yellow and annulate, with the tube about 1 cm. long, whilst the limb has almost rotund lobes up to 8 mm. long. In long-styled flowers the style is as long as the corolla tube, whilst the stamens are inserted in the middle of the tube. The capsule is globose, included in the calyx, and dehisces rather irregularly at the apex.

SIKKIM. Above Toong (*Cooper*, 349—*type*, 893).

Though Cooper collected fruiting specimens of this plant it is doubtful if it has ever been in cultivation. At the May meeting of the Royal Horticultural Society in 1919, an Award of Merit was given to Messrs. Bees of Liverpool for a plant which they exhibited as *P. Cooperi*. This plant is described in the Journ. Roy. Hort. Soc., xlv (1919), Proc. page cv as follows: "This primula is of tufted growth and produces spikes carrying large clusters of deep violet-purple coloured flowers, somewhat deeper in colour round the eye. The individual blooms are about ¾ inch across. The leaves are long lanceolate, with finely serrated margins and mealy underneath. The plant grows about 1 foot high and is said to be quite hardy." Whatever this plant may have been it was most certainly not *P. Cooperi*.

P. helodoxa Balf. f. in Notes Roy. Bot. Gard. Edin., ix, 171 (1916); Forrest in Journ. Roy. Hort. Soc. London, xli, 201 (1915); *ibid.*, xlii, Proc. clviii (1916); *ibid.*, xlvii, Proc. xliii (1922); Kingdon Ward, *ibid.*, xlix, 152, 153 (1924); *ibid.*, liv, 43, 64, 65, 71, 79 (1929); Gard. Chron., Ser. 3, lix, 286, figs. 123, 124 (1916); *ibid.*, lxix, 55 (1921); *ibid.*, lxx, 9, 50, 78, 128 (1921); *ibid.*, lxxxiii, 248 (1928); *ibid.*, lxxxiv, 473 (1928); *ibid.*, lxxxviii, 70 (1930); Garden, lxxx, figs. on pp. 255, 367, 368 (1916); *ibid.*, lxxxiv, fig. on p. 597 (1920); W. W. Sm. et Forrest in

Notes Roy. Bot. Gard. Edin., xvi, 17 (1928); Bot. Mag., t. 8899 (1938).

P. helodoxa is a native of the extreme west of Yunnan. Forrest discovered the plant in 1912 on the foothills around Tengyueh. There it grew in abundance, at the low altitude of 2000 metres, in open windswept and unsheltered situations, by streams, in marshy meadows, and on clayey pasture land. Later Forrest refound the plant in Burma, on the N'Maikha-Salwin divide, and in Burma it has also been collected by Kingdon Ward and by Kermode at Myitkyina, near the Feng-shui-ling Pass. Its closest ally is *P. Smithiana* Craib, a native of Chumbi and Bhutan. Professor Balfour suggested that the two forms might prove "to be geographical micro-forms of an aggregate." Long experience of both in cultivation does not support this view, for *P. Smithiana* is a much smaller plant with corollas much less broad in the limb and much shorter in the tube. These characters, together with the facts of distribution, appear strong enough to warrant specific rank for both plants.

This beautiful species grows to a height of 120 cm. The leaves are broadly oblanceolate, oblong-obovate or lanceolate, up to 35 cm. long and 7 cm. broad, obtuse or round at the apex, very markedly tapering at the base into the usually long winged petiole, denticulate at the margin, glabrous and efarinose on both surfaces, or sometimes faintly farinose below. The tall sturdy scape is 100–120 cm. in height and carries from four to six umbels of flowers, with up to twenty flowers in the umbel. Farina is present on the nodes of the scape and to a lesser degree on the bracts and pedicels. The bracts are linear to linear-lanceolate and subfoliaceous, sometimes faintly toothed at the margin, subconnate at the base; sometimes they are half as long as the pedicels, sometimes longer, thus varying in length from 0·5–3 cm. Campanulate and about 5–7 mm. long, the calyx is densely covered with cream or yellow farina without, is efarinose within, and is lobed for a third of its length, the lobes being triangular and hydathode-apiculate at the apex which is often slightly recurved. Fragrant and bright golden yellow, the annulate corolla is at least 2·5 cm. across the limb and the tube is about three times as long as the calyx. The lobes of the corolla are obovate, conspicuously emarginate and about 8 mm. long and broad.

In long-styled flowers the style is as long as the corolla tube, whilst the stamens are inserted 3 mm. above the base of the tube.

YUNNAN. Hills west of Tengyueh (*Forrest*, 7561—*type*); hills north-west of Tengyueh (F. 11906); Shweli Valley (F. 29414, 29480); without precise locality (F. 9802).

BURMA. N'Maikha-Salwin divide (*Forrest*, 29732). Feng-shui-ling Pass (*Kingdon Ward*, 1635); Myitkyina, about ¼ mile from Chinyinku (*Kermode*, 17145); Myitkyina, near Feng-shui-ling Pass (K. 17219).

Forrest's plant was first recorded as flowering in cultivation in 1916 by Messrs. Wallace of Colchester who gained an Award of Merit at the May meeting of the Royal Horticultural Society in that year. At the Society's May meeting in 1921 Mr. Lionel de Rothschild gained a First Class Certificate for this plant. Now it is a well-known garden plant and requires a natural situation in the open, among grass, where there is an adequate moisture supply.

P. ianthina Balf. f. et Cave in Notes Roy. Bot. Gard. Edin., ix, 175 (1916); W. W. Sm. et Forrest, *ibid.*, xvi, 17 (1928), and in Journ. Roy. Hort. Soc. London, liv, 43 (1929); Kingdon Ward in Gard. Chron., Ser. 3, lxxxviii, 71 (1930).

This Sikkim plant, most closely allied to *P. Beesiana* and to *P. pulverulenta*, is easily separable from these species by its sulphur-coloured farina, and thus bears almost the same relationship towards them as does *P. Miyabeana* to *P. japonica* and to *P. burmanica*. Its discovery we owe to Mr. Cave who collected it on four different occasions in Sikkim, in 1914, 1915, 1922, and 1925.

The leaves of this species are oblong-oblanceolate, up to 25 cm. long, 5 cm. broad, round at the apex, strongly tapering at the base into the winged petiole which is vaginate at the base, hydathode-denticulate at the margin, foveolate-glandular on both surfaces, and with potentially farinose glands on the lower surface. The strong scape is up to 60 cm. tall and is sulphur-farinose at the nodes, where there are three whorls of up to twelve flowers, which are carried on slightly farinose pedicels about 1 cm. long and are supported by lanceolate, acuminate, sulphur-farinose bracts 5–10 mm. long. In fruit the pedicels elongate to twice their length. Cupular-campanulate, the calyx is about 5 mm. long, is densely yellow-farinose without and only sparsely so within, and is divided to the middle into five triangular-deltoid acuminate teeth. The tube of the violet corolla is little more than twice as long as the calyx, whilst the limb, 1·5–2 cm. in diameter, has the lobes obcordate to rotundate, nearly 1 cm. in diameter and emarginate. The flowers are dimorphic, the style reaching the mouth of the throat or sometimes slightly exserted, and the stamens being inserted towards the base of the corolla. The capsule is globose-ovoid.

SIKKIM. Sandakphu (*Cave* in 1914—*type*, in 1915, No. 7247, and in 1925). Megu, Primula No. 8 (*Cave* in 1922).

Seeds of *Cave* 7247 were sent to the Edinburgh Botanic Garden in 1915 and plants were brought to the flowering stage. It was always a rare plant in gardens, but for some years did well in the Edinburgh Rock Garden. The species is no longer in cultivation in Edinburgh and is doubtfully so in any other garden.

P. imperialis Junghuhn in Tijdschrift Nat. Gesch., vii, 298 (1840); Miquel, Fl. Ind. Bat., ii, 1001 (1856); Watson in The Garden, xl, 266, t. 873 (1891); Hook. f. in Bot. Mag., t. 7217 (1892); Knuth, Handb. Blütenbiol., iii, 11, 12 (1905); Pax in Engler's Pflanzenr. Primulaceae, 125 (1905); Karsten und Schenck, Veg. Bild., vii, t. 3a (1909); Koorders Exkursions Fl. Java, iii, 33 (1912); Journ. Roy. Hort. Soc. London, xxvii, Proc. lxxxviii (1902); Watt, *ibid.*, xxix, 315, 316 (1904), and xxxix, 212, 213 (1913); W. W. Sm. et Forrest, *ibid.*, liv, 43 (1929), and in Notes Roy. Bot. Gard. Edin., xvi, 17 (1928). *P. prolifera* Hook. f. in Fl. Brit. Ind., iii, 489 (1882)—pro parte; Pax in Engler's Bot. Jahrb., x, 218 (1889)—pro parte. *Cankrienia chrysantha* De Vriese in Jaarb. Maatsch. van Tuinb., 30 (1850).

Inhabiting the high mountains of Java, where it was discovered by Junghuhn, a Dutch botanist of the Buitenzorg Botanic Gardens, this species was for many years confused with *P. prolifera* Wall. The confusion started in 1882 when Sir Joseph Hooker in the Flora of British India, vol. iii, p. 489, identified Wallich's plant from the Khasia Hills as the same as the Javan *P. imperialis*. In 1884 Hooker went still further, for in his article in the Botanical Magazine, t. 6732, under the heading of *P. prolifera*, he extended the distribution of what he called *P. prolifera* beyond Java and the Khasia Hills into the Eastern Himalaya. Pax, in Engler's Bot. Jahrb., in 1889, followed Hooker in uniting *P. prolifera* with *P. imperialis*, but in his monograph of the genus in Engler's Pflanzenreich in 1905 he separated the Indian and Javan plants. He did not realise, however, that *P. prolifera* is a completely efarinose plant confined to the Khasia mountains, for he quotes under *P. prolifera* several collections from Chumbi in the Eastern Himalaya which have a farinose inflorescence. Pax and Hooker thus made the same error. Actually the collections from the Eastern Himalaya with the farinose inflorescence upon which Hooker partly based his article on *P. prolifera*, and which Pax quoted in part for *P. prolifera*, represented something quite new and which was later described by Craib as *P. Smithiana*.

This species forms a rosette of elongate-obovate to spathulate leaves up to 35 cm. long and 8 cm. broad, round at the apex, very strongly tapering at the base into the prominently winged petiole, finely denticulate at the margin, rugose on the upper surface and yellow farinose below, sometimes faintly, sometimes conspicuously so. The scape, which is farinose at the nodes, is very much longer than the leaves and bears from two to four tiers of numerous flowers which arise from the axils of usually broadly ovate slightly farinose bracts; these are leaf-like at the apex and up to 2 cm. long. For the greater part of their length the pedicels are upright and then usually suddenly pendent at the apex and are up to 3 cm. long. The calyx is quite strongly farinose without, slightly farinose within, is cup-shaped and from 4–7 mm. long and is lobed to the middle, the lobes being triangular and obtuse, each lobe terminating in a hydathode. Bright yellowish-orange, the corolla has its tube twice as long as the calyx while the limb, 1–1·5 cm. in diameter, has broadly elliptic to almost oblong and slightly emarginate lobes. The flowers are monomorphic, the stamens being inserted slightly below the mouth of the corolla tube and the stigma reaching the height of the stamens. In fruit the pedicels are upright for the whole of their length, whilst the globose capsule is as long as the calyx.

JAVA. Preanger (*Warburg*, 3039). Pangerango (*Boeth*, 102).

P. imperialis first flowered in this country in 1892, from seeds which were sent to Kew from the Buitenzorg Gardens in 1889. In 1902 it received an Award of Merit from the Royal Horticultural Society when exhibited by Messrs. Veitch. It is still in cultivation in Edinburgh, through seed which was collected in Java in 1938 and sent to the Botanic Garden by Prof. A. Ernst. This is also the case with the following variety.

P. imperialis Jungh. var. **gracilis** Pax in Engler's Pflanzenr. Primulaceae, 125 (1905).

This variety differs from the species in having the tube of the corolla only as long as the calyx and not twice as long.

JAVA. *Zollinger*, 2962—*co-type.*

P. japonica A. Gray in Mem. Amer. Acad., new ser., vi, 400 (1857): Miq., Prolusio Fl. Japon., 283 (1866); Hook. f. in Bot. Mag., t. 5916 (1871); André in Illust. Hort., xviii, 134, t. 69 (1871): Regel in Gartenflora, xxi, 195, t. 729 (1872): *ibid.*, xxvii, 22-23 (1878); Fl. des Serres, xix, 31, t. 1950–1951 (1873); Scharlok in Flora, 207 (1878); Useful Pl. Japan, iii, t. 901 (1895); Pax in Engler's Bot. Jahrb., x, 218, excl. var. (1889), and in Engler's Pflanzenr. Primulaceae, 125 (1905); Journ. Roy. Hort. Soc. London, iii, Proc. lxx (1872); *ibid.*, xxv, Proc. lxxxviii (1900); *ibid.*, xxvii, Proc. lxxxvi (1902); *ibid.*, xxxix, 166, 175, 179, 183, 213, 220, figs. 96 and 97 (1913); *ibid.*, liii, Proc. xxxvii (1928); *ibid.*, liv, 43, 64, 65, 71, 79 (1929); Gard. Chron., Ser. 3, xcvi, 377, 431, 450 (1934); *ibid.*, xcvii, 52 (1935); *ibid.*, cii, 45, 106 (1937); The Garden, lxxviii, 280 (1914); *ibid.*, lxxxii, 237 (1918); *ibid.*, lxxxiv, 577 (1920); Notes Roy. Bot. Gard. Edin., viii, t. 21 (1913); *ibid.*, xvi, 17 (1928).

Discovered by Charles Wright in 1855, near Hakodadi, it was in 1861 that this plant was found again by Fortune in gardens near Yedo. Plants and seeds were brought to England, but the former died on the voyage and the latter failed to germinate. In 1870, however, seeds which had been collected by a Mr. Kesurck of Hong Kong and by Messrs. Walsh, Hall & Co., of

Yokohama, did germinate in this country and plants were flowered by Mr. Ball of Chelsea in 1871. Since that time it has never ceased to be in cultivation in our gardens.

Except for the inside of the calyx lobes *P. japonica* is completely efarinose and is thus most closely related to *P. burmanica* Balf. f. et Ward. There can be no mistaking the two plants, however, for the flowers of the Japanese plant are monomorphic, whilst those of the Burmese plant are dimorphic.

The leaves of *P. japonica* are obovate-oblong to broadly spathulate, up to 25 cm. long and 8 cm. broad, round at the apex, strongly tapering at the base into the winged petiole or sometimes subsessile, finely and irregularly crenate-dentate at the margin. The sturdy scape rises to a height of 45 cm. and bears from one to six whorls of flowers. These arise from the axils of linear-lanceolate bracts and are borne on pedicels up to 2 cm. long. In fruit the pedicels are 3 cm. or more in length. The calyx is about 8 mm. long, whilst the lobes are triangular-subulate, half the length of the calyx and are covered on the inside with copious white or cream-coloured meal. Purplish red, the corolla has its tube almost three times as long as the calyx and the lobes of the limb, which is about 2 cm. in diameter, are obcordate. The flowers are monomorphic, the stamens being inserted at the mouth of the corolla or slightly below the mouth.

JAPAN. At Nikko in 1910 (*Mochizuki*). At Tomokomai, province of Iburi, in 1924 (*Tatewaki*). In the province of Musachi in 1909 (*Yokohama Nursery Company*).

It is true that many of the forms of this well-known primula are not desirable plants, but it is equally true that there are some particularly good forms. There is one which approaches the best forms of *P. Beesiana*, having rich rose-purple flowers; another has pure rose flowers without a trace of magenta. But the best form of all is possibly that known as "Postford White"—a very robust plant with tall stout scapes, tinged with purple often, and bearing several tiers of large pure white flowers with a yellow eye. Seedlings of this variety come perfectly true from seed. *P. japonica* is easy of cultivation and is happiest in a moist shady spot in rich rather heavy loam. It is a perennial, but should, however, be frequently raised from seeds.

P. khasiana Balf. f. et W. W. Sm. in Notes Roy. Bot. Gard. Edin., ix, 176 (1915); W. W. Sm. et Forrest, *ibid.*, xvi, 17 (1928), and in Journ. Roy. Hort. Soc. London, liv, 43 (1929).

Only two Candelabra primulas are to be found in the Khasia Hills, *P. khasiana* and *P. prolifera.* The latter is confined solely to the Khasia Hills, whilst the former extends also to the Naga Hills. The two plants were for a long time confused, and Sir George King apparently suspected this confusion for on a sheet of *P. khasiana* in the Calcutta Herbarium named *P. prolifera* and dated 1850 he wrote, "The flower of *P. prolifera* is yellow: these appear to have been purple." The flowers of *P. khasiana*, however, are not purple but yellow, for on the label of a sheet in the Calcutta Herbarium collected in the Naga Hills by the Reporter on Economic Products to the Government of India in 1895, and numbered 11543 (which was named *P. prolifera*, but which is undoubtedly *P. khasiana*), the flower colour is described as "lemon-yellow." Certainly the two plants are very closely allied. There is, however, one character, that of the bracts, which if valid renders the two species separable. The bracts of *P. prolifera* are subulate to lanceolate and are much shorter than the pedicels; those of *P. khasiana* are longer than the pedicels, sometimes very much so, and are subfoliaceous towards the apex. Apart from this, *P. khasiana* is a far more leafy plant than the other, and the lateral veins leave the midrib at an acute angle, and not more or less at a right angle as in *P. prolifera*. Nevertheless further collections of these two species in Assam are much needed.

P. khasiana is a completely efarinose plant with leaves which are lanceolate, up to 25 cm. long and 3 cm. broad, round or obtuse at the apex, strongly tapering at the base into the broadly winged and hardly differentiated petiole, finely denticulate at the margin, glandular-punctate on both surfaces and with the lateral veins arising from the midrib at an acute angle. The scape is twice as long as the leaves and carries a compact umbel of yellow flowers or two superposed umbels. Bracts and pedicels may be the same length, or the former may be as long as the pedicel and flower together, and subfoliaceous at the apex. The calyx is tubular-campanulate, 6–7 mm. long and is lobed to the middle, the lobes being lanceolate, acuminate, and hydathode-apiculate. The subventricose tube of the annulate corolla is at most twice as long as the calyx, whilst the corolla limb, with its bilobulate obovate lobes, is 1·5 cm. in diameter. In pin-eyed flowers the style is as long as the corolla tube, whilst the stamens are inserted near the base of the tube. On the other hand, in thrum-eyed flowers the stamens are inserted just above the middle of the corolla tube and the style is shorter than the calyx.

This rare plant, which has never been in cultivation and the type of which, collected in 1850 by a native collector in the Khasia Hills, is in the Calcutta Herbarium, is represented in the Edinburgh Herbarium as follows:—

ASSAM. Khasia Hills (*native collector* in 1850—*co-type*). Naga Hills, Konoma, in 1895 (*Reporter on Economic Products to the Government of India*, 11543).

P. mallophylla Balf. f. in Notes Roy. Bot. Gard. Edin., ix, 181 (1916), and in Journ. Roy. Hort. Soc. London, xxxix, 134, 166, 167 (1913); W. W. Sm. et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 17 (1928), and in Journ. Roy. Hort. Soc. London, liv, 43 (1929); Hand.-Mzt., *ibid.*, liv, 52 (1929).

P. mallophylla was described from a collection of P. G. Farges (F. 1181), made in Eastern Szechuan in the district of Tchen-Keou-tin. Part of Farges 1181 was sent to Edinburgh and to Kew from the Paris Herbarium under the name of *P. japonica*. Some additional material of Farges 1181 went to Kew, bearing the name *P. angustidens* Pax. With *P. japonica* the plant bears no close relationship, for it is completely efarinose, whereas the Japanese species has copious meal on the inside of the calyx. Moreover, the latter plant has monomorphic flowers, whereas the flowers in Balfour's species are most decidedly dimorphic. The relationship to *P. angustidens*, or *P. stenodonta* Balf. f. as Pax's species should now be called, is much more close for both have dimorphic flowers and both have bracts at least as long as the pedicels. The bracts of *P. stenodonta* are, however, linear, whilst those of *P. mallophylla* are linear-lanceolate to oblong-elliptic and subfoliaceous. Again, the former plant has reddish-violet flowers, whilst the latter has orange-coloured flowers. Most important of all, the scape of *P. mallophylla* is markedly puberulous towards the apex, and in this the species is quite unlike any other in the section.

In 1914 Schneider refound the plant in Southern Szechuan, but at the time his collections were named *P. Bulleyana* Forrest. These collections may partly be responsible for Stapf's statement in the Botanical Magazine, t. 9026, under *P. Bulleyana*, that Schneider found Forrest's plant in Southern Szechuan. Actually *P. Bulleyana* is confined to Yunnan.

P. mallophylla is an efarinose species with oblong to oblong-obovate leaves 12–18 cm. long and 4–6 cm. broad, round at the apex, tapering at the base into the short broadly winged petiole, and irregularly denticulate to erose at the margin. The sturdy scape is up to 30 cm. tall, is markedly puberulous at the apex and carries either a single terminal umbel or two to three superposed umbels with up to fifteen flowers in the umbel. These flowers are borne on pedicels only a little over 1 cm. long and these are supported by bracts up to 3 cm. long, the outermost ones being oblong-elliptic and foliaceous and the inner ones linear to linear-lanceolate. The calyx is cup-shaped to tubular, varies in length from 7–14 mm. and is divided to below the middle into lanceolate, hydathode-apiculate lobes. Markedly annulate and a deep yellow, the corolla is 1·5 cm. across the limb and is conspicuously dimorphic. In pin-eyed flowers the corolla tube is only a little longer than the calyx, the style is prominently exserted and the stamens are inserted half-way up the tube. On the other hand, in thrum-eyed flowers the corolla tube is about twice as long as the calyx, the stamens are inserted a little below the annulus, and the style is almost as long as the calyx.

This is a rare plant in herbaria and is represented in Edinburgh by the type and by Schneider's specimens.

EASTERN SZECHUAN. District of Tchen-Keou-tin (*Farges*, 1181—*type*).

SOUTHERN SZECHUAN. Between Kalapa and Linku (*Schneider*, 1271, 1403).

This species has never been in cultivation.

P. melanodonta W. W. Sm. in Notes Roy. Bot. Gard. Edin., xv, 303 (1927); W. W. Sm. et Forrest, *ibid.*, xvi, 17 (1928), and in Journ. Roy. Hort. Soc. London, liv, 43 (1929).

Kingdon Ward discovered this plant at Seinghku Wang and in the Seinghku Valley on the Burma-Tibet Frontier, in 1926. It was growing abundantly at an altitude of 3500 to 4000 metres on muddy alpine slopes and by the sides of streams. In the same area but at a higher altitude Ward also found *P. serratifolia* and undoubtedly the two plants are closely allied. *P. melanodonta*, however, has much smaller leaves, the scape being 3–5 times as long as the leaves and not simply twice as long as in the other species. There is also the difference in the flowers, which are concolorous and not bicolorous as in true *P. serratifolia*.

P. melanodonta has small oblanceolate or obovate leaves, 3–5 cm. long and 1·5–2 cm. broad, round or obtuse at the apex, markedly tapering at the base, deeply dentate at the margin, and with a thin covering of potentially farinose glands on the lower surface. The efarinose scapes, one to three to each plant, rise to a height of up to 25 cm.; usually there is a single umbel of three to five flowers, though sometimes two superposed umbels are produced. The flowers have pedicels 5–10 mm. long, which elongate to 2 cm. in fruit, and these arise from the axils of linear to linear-lanceolate purple bracts 5 mm. long. Campanulate and 7–10 mm. long the calyx is markedly five-angled and is cut almost to the middle into ovate, acuminate, spreading purple teeth. Bright yellow, with a deeper yellow annulus, the corolla has the tube half as long again as the calyx, and the flat spreading limb, 2 cm. in diameter, has the lobes broadly obcordate, about 8 mm. long and deeply emarginate. In pin-eyed flowers the style is as long as the calyx, whilst the stamens are inserted towards the base of the corolla tube.

Only Kingdon Ward has collected this plant, which has never been in cultivation.

BURMA-TIBET FRONTIER. Seinghku Wang (*Kingdon Ward*, 6901—*type*, 7042); Valley of the Seinghku (K. W., 7536).

P. microloma Hand.-Mzt. in Anz. Akad. Wiss. Wien, lxi, 134, Taf. xiii, Abb. 6 (1924), and in Symbolae Sinicae, vii, 749 (1936); W. W. Sm. et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 17 (1928), and in Journ. Roy. Hort. Soc. London, liv, 43 (1929); Hand.-Mzt., *ibid.*, liv, 61 (1929).

This is a rare plant, collected only once by Dr. Handel-Mazzetti in N.W. Yunnan in the mountains of the Salwin-Irrawady divide. He found it growing in the cold temperate zone under Rhododendrons in the Fir forest at an altitude of 3700 metres. It belongs to that small group of closely allied efarinose species with monomorphic flowers, *P. brachystoma* W. W. Sm., *P. Morsheadiana* Ward, *P. prenantha* Balf. f. et W. W. Sm., and *P. polonensis* Ward, but stands alone in having white flowers instead of yellow ones.

The obovate leaves are up to 9 cm. long and 3 cm. broad, round at the apex, attenuate at the base, deeply dentate at the margin and with a few potentially farinose glands on the lower surface. To each plant there are one to two scapes, and these are efarinose and up to 26 cm. long, carrying one to two umbels of from two to six flowers. The flowers have nodding pedicels up to 2 cm. long, whilst the bracts are subulate-linear and are at most 1 cm. long. Campanulate and 5–6 mm. long, the calyx has five short triangular teeth 1·5 mm. long. The infundibuliform and markedly annulate corolla is white and has the tube at most twice as long as the calyx, whilst the limb is 5 or 6 mm. in diameter. Obviously monomorphic, the style is slightly longer than the calyx. The capsule is globose and is as long as the calyx.

The type of this species is in the Vienna Herbarium and a co-type is in Edinburgh. There is no record of the species having been in cultivation.

N.W. YUNNAN. Mountains of the Salwin-Irrawaddy divide (*Handel-Mazzetti*, 9215—*co-type*).

P. Miyabeana Ito et Kawakami in Miyabe-Festschrift, i, t. 29 (1911); Bot. Mag., t. 8606 (1915); Balf. f. in Journ. Roy. Hort. Soc. London, xxxix, 166, 179 (1913); W. W. Sm. et Forrest, *ibid.*, liv, 43 (1929); McLaren, *ibid.*, liv, 65 (1929); W. W. Sm. et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 17 (1928). *P. japonica* A. Gray var. *Miyabeana* A. Ito in Encycl. Jap., iv, 778 (1880).

This endemic of Formosa was introduced to cultivation by Mr. W. R. Price, who found the species on Mount Morrison at an altitude of 2300 metres. He collected seeds which were sent to Kew in 1913. These germinated and the resulting plants flowered in May 1914. It is related to *P. japonica* and to

P. burmanica in that the farina is present only on the inside of the calyx lobes. The farina is, however, a brilliant sulphur-colour and not white as in the other species. Apart also from minor differences in the calyces of these three plants, the characters of the corolla are quite strong enough to separate the Formosan species, for the corolla tube is gradually ampliate from the base, and not cylindrical and ampliate only towards the apex, as in the other two species.

The leaves of this species are obovate-oblong to oblanceolate up to 20 cm. long and 5 cm. broad, obtuse or acute at the apex, tapering at the base to the very broadly winged petiole which is vaginate at the base, irregularly denticulate at the margin, and with a thin covering of potentially farinose glands on the lower surface. The scape is 60 cm. or more in height, is efarinose, and carries from two to four whorls of flowers, with six to ten flowers to each whorl. The flowers are borne on pedicels 1–2 cm. in length, and these are supported by linear-subulate bracts, 1 cm. long. Campanulate and bright yellow-farinose within, the calyx is 5–6 mm. long, and is lobed almost to the middle, the lobes being triangular and acuminate. The tube of the purple corolla is twice as long as the calyx, whilst the limb is 1·5 cm. in diameter, annulate at the mouth and has the lobes emarginate and crenate-serrate. In the monomorphic flowers the style reaches the mouth of the corolla where the stamens are inserted.

No native specimens are in the Edinburgh Herbarium and the species is represented by two cultivated specimens, one grown in the Edinburgh Royal Botanic Garden in 1919 and the other in Galloway House Gardens, Garlieston, Wigtownshire, in 1928.

EASTERN ASIA. Island of Formosa, on Mount Morrison.

P. Morsheadiana Ward in Notes Roy. Bot. Gard. Edin., xv, 70 (1925); W. W. Sm. et Forrest, *ibid.*, xvi, 17 (1928), and in Journ. Roy. Hort. Soc. London, liv, 43 (1929); Kingdon Ward, *ibid.*, lii, 232 (1927), and in Gard. Chron., Ser. 3, lxxxviii, 71 (1930).

The close relationship of this plant to *P. prenantha* is discussed under the latter species. Discovered by Kingdon Ward on the Doshong La in S.E. Tibet in 1924, *P. Morsheadiana* has elliptic to oblanceolate leaves up to 12 cm. long and

3 cm. broad, obtuse or round at the apex, strongly attenuate at the base into the winged petiole, irregularly denticulate at the margin, glabrous and efarinose on both surfaces, but minutely and sparsely glandular-punctulate below. At first the scape is as long as the leaves, but later elongates to almost twice that length and carries a single umbel of three to ten nodding flowers. These are borne on pedicels 5–15 mm. long, which arise in the axils of linear to linear-lanceolate bracts up to 5 mm. long. The campanulate calyx is about 5 mm. long, strongly five-nerved, sparsely covered with potentially farinose glands and is lobed for a third of its length into broadly triangular, hydathode-apiculate lobes. Golden yellow, distinctly annulate and monomorphic, the corolla has the tube about twice as long as the calyx, and the limb, 1 cm. or more in diameter, has rotundate to obovate lobes, 5 mm. long, slightly crenulate, emarginate, and mucronulate. The stamens are inserted in the middle of the corolla tube, and the capsule is as long as the calyx.

S.E. TIBET. On the Doshong La (*Kingdon Ward*, 5858—*co-type*, 6237). On the Chubumbu La (*Ludlow, Sherriff and Taylor*, 3986); Tsari Sama, Langong (*Ludlow, Sherriff and Taylor*, 5587); also *Ludlow, Sherriff and Taylor*, 4954, 4954B.

The species has never been in cultivation.

P. Poissonii Franch. in Bull. Bot. Soc. France, xxxiii, 67 (1886); Pax in Engler's Bot. Jahrb., x, 218 (1889); Forbes et Hemsl. in Journ. Linn. Soc. Bot., xxvi, 41 (1889); Hook. f. in Bot. Mag., t. 7216 (1892); Gard. Chron., Ser. 3, ix, 729 (1891); *ibid.*, xii, 649 (1892); *ibid.*, xlvi, 344, with illust. (1909); *ibid.*, lvii, 352, fig. 119 (1915); The Garden, xl, 354, pl. 827 (1891); *ibid.*, lxii, 81, with fig. (1902); Balf. f. in Journ. Roy. Hort. Soc. London, xxxix, 130, 136, 159, 166–8 (1913); Forrest, *ibid.*, xli, 201, 203 (1915), and xlii, 45 (1916); Kingdon Ward, *ibid.*, xlviii, 203–4 (1923); W. W. Sm. et Forrest, *ibid.*, liv, 13, 43 (1929); Hand.-Mzt., *ibid.*, liv, 55–56 (1929); McLaren, *ibid.*, liv, 65 (1929); Gould, *ibid.*, liv, 70 (1929); W. W. Sm. et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 17 (1928); Farrer in English Rock Garden, ii, 69, pl. 19 (1919); Hand.-Mzt. in Symbolae Sinicae, vii, 749 (1936). *P. planiflora* Hand.-Mzt. in

Journ. Roy. Hort. Soc. London, liv, 55 (1929), in adnot. and in Symbolae Sinicae, vii, 750 (1936).

Delavay discovered this plant in fruit in 1882 near Tali, and again in 1883, this time in flower, on Mount Hee-chan-men, above Lankong, at an elevation of between 2800 and 3000 metres. Seeds were germinated in Paris and seedlings presented to the Royal Botanic Gardens, Kew, by the Jardin des Plantes, Paris, in 1890; these seedlings flowered in April 1891. *P. Poissonii* forms the centre of a group of four closely related species, all of which are completely efarinose. The three other species are *P. stenodonta*, *P. Wilsoni*, and *P. anisodora*. *P. stenodonta* is readily distinguished by its lanceolate, long-acuminate calyx segments; in the other species the calyx teeth are short and triangular. *P. Wilsoni* and *P. anisodora* can be separated from Franchet's plant by the fact that they are markedly aromatic, whereas the other is non-aromatic, and by the smaller corollas. In *P. Poissonii* the corolla limb is patent and measures 2–3 cm. in diameter and the lobes are deeply emarginate. In the garden *P. anisodora*, with its deep blackish-purple and greenish-eyed flowers, can never be confused with the pale purple to red-flowered and yellowish-eyed *P. Wilsoni*. *P. planiflora*, with its flat corolla limb, seems to us to be undoubtedly *P. Poissonii* and certainly the Forrest collections quoted by Handel-Mazzetti (F. 355, 1819, 2120) cannot be distinguished from a co-type of *P. Poissonii* (Delavay, 120) which is in the Edinburgh Herbarium. The type is in the Paris Herbarium.

This completely efarinose non-aromatic species has glaucous oblong-obovate leaves up to 18 cm. long and 4 cm. broad, round at the apex, strongly tapering at the base into the petiole which is sometimes hardly differentiated and at other times conspicuously winged. The lamina, even at maturity, tends to be somewhat involute and the margin is regularly denticulate. The scape rises to a height of up to 45 cm. and bears from two to six tiers of flowers. The linear bracts are up to 1 cm. long, whilst the pedicels are 1–2 cm. long and, especially in fruit, are closely adpressed to the scape. Cup-shaped and often covered with reddish striae, the calyx is about 5 mm. long and is lobed for a third to a half of its length, the lobes being triangular to oblong and usually obtuse. Deep purplish crimson, with a yellow eye, or occasionally white, the flat limb of the corolla is 2–3 cm. in diameter, whilst the tube is two to three times as long as the calyx and the throat is distinctly annulate. The lobes of the limb are patent, obcordate, and distinctly emarginate, usually very deeply so, and sometimes slightly crenate. In pin-eyed flowers the stamens are inserted at the base of the corolla tube, whilst the style is half as long as the corolla tube. The style in thrum-eyed flowers is only 1 mm. long, whilst the ovary is 1·5 mm. in diameter and has a five-lobed crown. The ovoid capsule is usually about as long as the calyx or at most only slightly longer.

This is a well-known species in gardens and in herbaria and in the Edinburgh Herbarium is thus represented:—

YUNNAN. Hee-chan-men, Lankong (*Delavay*, 120—*co-type*); boggy places in the Lichiang and Hoching valleys (*Forrest*, 355); eastern flank of the Lichiang (F. 6014); north end of the Lichiang valley (F. 2120); Lichiang range (F. 30303); eastern flank of the Tali range (F. 1819); Tali (F. 30191): Chungtien plateau (F. 12792—white form); on the Li-ti-ping (F. 19465): Chienchuan-Mekong divide (F. 23244); Yungbu Shan (F. 30265); Lanping Shan (F. 30297); Hsiao Chungtien (F. 30196); Wei Hsi (F. 30225); Fuchuan Shan (F. 30233). Yunnan Sen (*Ducloux*, 886). Near Yungpelting (*Schneider*, 3478). Mount Satseto, on the Lichiang Snow Range (*Rock*, 24837); on Lao-chun-shan, S.W. of Shi-Ku and Yangtze (R. 25100, 25410); mountains of Ludu, N.W. of Lichiang, W. of Yangtze (R. 18522).

SZECHUAN. Tatsienlu (*Soulié*, 648), between Oti and Sanssiastung (*Schneider*, 1190). Mountains around Muli (*Forrest*, 28414). Mountains between the Litang and Shou-Chu rivers, between Wa-Erh-Dje and Garu (*Rock*, 16740); mountains of Kulu (R. 18209); Mount Gibboh (R. 24183, 24586).

P. polonensis Ward in Ann. Bot., xliv, 124 (1930); Ward in Gard. Chron., Ser. 3, lxxxviii, 71 (1930).

This species is related to *P. Morsheadiana* Ward, but is a much more robust plant with larger leaves and flowers. It has apparently been collected but once, in 1928, by Kingdon Ward in the Delei Valley, on the Assam Frontier, at an altitude of 2900 metres. The plant has oblong leaves up to 25 cm. long and 6 cm. broad, round at the apex, gradually tapering at the base into the broadly winged sheathing petiole, minutely denticulate at the margin and finely punctulate on the lower surface. The scape is up to 35 cm. tall and ends in a drooping umbel of bright yellow flowers or there may be two or even three superposed umbels. The bracts are linear-lanceolate, up to 1·5 cm. long, whilst the stout pedicels are 3 cm. long. Very prominently angular and 8–10 mm. long, the calyx is lobed almost to the middle, the lobes being ovate to triangular and acute. Markedly annulate the corolla has the tube a little longer than the calyx, whilst the limb is 2 cm. in diameter and has the lobes ovate to almost round, about 8 mm. long and usually round at the apex. The flowers are monomorphic, the stamens being inserted near the middle of the corolla tube, and the style is half as long as the tube. The type specimen, *Kingdon Ward*, 8388, is in the Herbarium of the British Museum and a co-type is in Edinburgh.

Assam Frontier. Delei Valley (*Kingdon Ward*, 8388—*co-type*).

P. polonensis first flowered in the garden of the late Mr. H. Barton, of The Bush, Co. Antrim, in 1930, and in April and May of the following year fine specimens flowered in pots which stood in the cool house with their bases in a water tank in the Royal Botanic Garden, Edinburgh. The species is still in cultivation in Edinburgh.

P. prenantha Balf. f. et W. W. Sm. in Notes Roy. Bot. Gard. Edin., ix, 191 (1915); W. W. Sm. et Forrest, *ibid.*, xvi, 17 (1928), and in Journ. Roy. Hort. Soc. London, liv, 13, 43 (1929); Kingdon Ward in Gard. Chron., Ser. 3, lxxxviii, 71 (1930).

This species has a wide distribution in Sikkim, Assam, Bhutan, Burma, and Tibet. Except in the latter area, it is very uniform in appearance, being particularly characterised by its very small corollas which are always under 1 cm. in diameter, and the lobes of which are not patent but are more or less in line with the corolla tube. In South-Eastern Tibet, however, the species goes somewhat out of character; the flowers become larger and the petals more patent, and it is often then difficult to separate this plant from its close ally, *P. Morsheadiana*, which is confined to South-Eastern Tibet.

Given perfectly typical material, the two plants are quite distinct, for *P. Morsheadiana* has the corolla limb 1 cm. in diameter and the patent lobes are twice as long as the non-patent lobes of *P. prenantha*. Moreover, the capsule of the latter species is much smaller than that of the other. In South-Eastern Tibet there are, however, intermediate stages, which do not preclude the possibility of the two plants representing the same species.

P. prenantha, one of the smallest of all Candelabra primulas, has rosulate shortly petioled leaves up to 12 cm. long and 3 cm. broad, oblong-obovate, round at the apex, erose-denticulate at the margin, the teeth terminating in hydathodes, markedly tapering at the base, areolate on the upper surface and conspicuously and intricately veined on the lower surface where there is a thin covering of potentially farinose glands. In flower the scape is up to 15 cm. tall, elongating in fruit to 20 cm., pulverulent at the apex, and carries usually one, or sometimes two tiers of from four to eight small nodding yellow monomorphic flowers. These have puberulent pedicels up to 1·5 cm. long, which arise in the axils of acicular, reddish bracts, 5–10 mm. long. Tinged with red, and with five prominent ribs, the campanulate calyx is about 5 mm. long, and is very shortly lobed, the lobes being deltoid to elongate-triangular to liguliform and terminating in a hydathode. The tube of the corolla is 5–7 mm. long and is distinctly annulate, whilst the limb is under 1 cm. in diameter. The lobes of the limb are not patent but are more in line with the corolla tube, and are subquadrangular, 2–2·5 mm. long, and retuse. Inserted slightly below the annulus, the stamens are the same height as the calyx. The subglobose capsule is about 5 mm. in diameter and is longer than the calyx.

The type specimen is in the Calcutta Herbarium and the following collections are in Edinburgh:—

Sikkim. Jongri (*King's Collector*). Jongri (*Gammie*, 208). Half day from Jongri (*Cave*, 18).

Burma-Tibet Frontier. Seinghku Wang (*Kingdon Ward*, 6575, 6982); Valley of the Seinghku (K. W. 7499).

Tibet. Alpine regions of the Solo-La, Tsarong (*Rock*, 22247, 22675). On the Kashong La, Chayul Chu (*Ludlow and Sherriff*, 2396, 2732); Podzo Sumdo, Tsari Chu (*Ludlow and Sherriff*, 1658); Chickchar, Tsari (*Ludlow and Sherriff*, 2126);

Singo Samba, Langkong Chu (*Ludlow, Sherriff and Taylor*, 3848); on the Tsanang La (*Ludlow, Sherriff and Taylor*, 6523).

ASSAM FRONTIER. Delei Valley (*Kingdon Ward*, 8262, 8347).

BHUTAN. Singhi (*Cooper*, 4330); on the Rudong La (C. 4164).

P. prenantha first flowered in cultivation in this country in 1921 from seeds sent from Darjeeling in 1920. The plants, however, were soon lost. Several unsuccessful attempts have since been made to reintroduce the plant but it was not until 1938 that it was again brought to the flowering stage, when plants of *Ludlow and Sherriff*, 2516, flowered in the Royal Botanic Garden, Edinburgh. The species cannot be regarded as having any garden value.

P. prolifera Wall. in Asiat. Res., xiii, 372, t. 3 (1820), and in Roxb. Fl. Ind., ed. Carey, ii, 18 (1824); Duby in DC. Prodr., viii, 34 (1844); Hook. f. in Fl. Brit. Ind., iii, 489 (1882), pro parte; Bot. Mag., t. 6732 (1884), pro parte; Pax in Engler's Bot. Jahrb., x, 218 (1889), pro parte, and in Engler's Pflanzenr. Primulaceae, 124 (1905), pro parte; Balf. f. in Journ. Roy. Hort. Soc. London, xxxix, 166 (1913); Craib, *ibid.*, xxxix, 189, 190 (1913); W. W. Sm. et Forrest, *ibid.*, liv, 43 (1929), and in Notes Roy. Bot. Gard. Edin., xvi, 17 (1928).

Wallich's locality for this species was the Khasia Mountains. Pax, however, maintained that the distribution of the plant was Assam and the Eastern Himalaya. With Wallich's original description the Assam plant well agrees, but the Chumbi plant is something quite distinct, differing from Wallich's Assam plant in the presence of farina and in the shape of the calyx lobes. It was named and described by Craib as *P. Smithiana*, and is a very close ally of *P. helodoxa* (see discussion under *P. imperialis*, as to the confusion of *P. prolifera*, *P. Smithiana*, and *P. imperialis*). Wallich's plant was also presumed to include what is now *P. khasiana* (see statement under that species).

The leaves of this efarinose plant are oblong to subspathulate, up to 30 cm. long and 6 cm. broad, round or obtuse at the apex, strongly attenuate at the base, minutely denticulate at the margin, markedly glandular-punctate on the lower surface, and with the numerous pairs of lateral nerves arising from the midrib almost at a right angle. The scape is about twice as long as the leaves and carries either a single terminal umbel of flowers or two or three superposed umbels. Slightly nodding at the flowering stage, and upright when in fruit, the pedicels are up to 3 cm. long and are supported by subulate to lanceolate bracts, much shorter than the pedicels and slightly gibbose at the base. Tubular and with five prominent veins which make it markedly five-angled, the calyx is at most 5 mm. long and is divided to the middle or almost to the middle, the lobes being lanceolate and acute. The corolla is yellow, hypocrateriform and annulate, has its tube two to three times as long as the calyx, and the limb, 2 cm. in diameter, has obcordate, crenate, and emarginate lobes. In thrum-eyed flowers the stamens are inserted two-thirds up the corolla tube, whilst the style is hardly as long as the calyx. The globose capsule is about as long as the calyx.

ASSAM. Khasia Hills, Maobeh (*C. B. Clarke*, 43666 E).

This species has never been in cultivation. The plant figured under this name in Bot. Mag., t. 6732, is *P. Smithiana.*

P. pulverulenta Duthie in Gard. Chron., Ser. 3, xxxviii, 259 (1905); *ibid.*, xli, 391 (1907); *ibid.*, lvii, 197 (1915); *ibid.*, lxxvii, 378, 402 (1925); *ibid.*, lxxx, 309, fig. 143 (1926); *ibid.*, xcvi, 413 (1934); *ibid.*, xcvii, 66 (1935); The Garden, lxxviii, 22, 119 (1914); Farrer in English Rock Garden, ii, 172, pl. 18 (1919); Journ. Roy. Hort. Soc. London, xxxvii, Proc. cxxxvi (1911); *ibid.*, xxxix, 136, 137, 166, fig. 76 (1913); *ibid.*, l, Proc. xlviii (1925); *ibid.*, li, 87, 88 (1926); *ibid.*, liv, 43, 64, 65, 70, 78 (1929); W. W. Sm. et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 18 (1928). *P. serratifolia* Pax in Engler's Pflanzenr. Primulaceae, 126 (1905), pro parte—non Franchet.

E. H. Wilson collected *P. pulverulenta* on the mountains of Western Szechuan, and sent home seed of it to Messrs. Veitch in 1905. Very quickly it became established in cultivation. Previous to 1905 it had been collected in the same province by Henry (H. 8879) and by Pratt (P. 130, 356), and Duthie's description is based on cultivated material from Messrs. Veitch and on the collections of Henry and Pratt.

This robust perennial plant has a short stout rootstock from which arise the obovate or oblanceolate leaves, which are up to

30 cm. long and 10 cm. broad, round at the apex, conspicuously tapering at the base into the winged petiole, regularly or irregularly dentate or sometimes obscurely lobed at the margin and prominently veined on the lower surface, where there is a thin covering of potentially farinose glands. The scape is up to 100 cm. in height and bears many superposed umbels of flowers. The scape, pedicels, and calyx are all covered with white farina. The pedicels are spreading, up to 2 cm. long in flower and longer in the fruiting stage, whilst the calyx, white farinose within, is up to 8 mm. long and is lobed to the middle or almost to the middle, the lobes being triangular and acuminate. Red with a darker red or purple eye, the corolla has the tube about twice as long as the calyx, whilst the limb with its ten-lobed annulus is 2-3 cm. in diameter. The lobes of the limb are obcordate and deeply emarginate. In pin-eyed flowers the style reaches to the mouth of the corolla tube, and the stamens are inserted slightly above the middle of the tube.

WESTERN SZECHUAN. Near Tatsienlu (*Pratt*, 130). Tahsiangling (*Harry Smith*, 10188).

Since it was first introduced in 1905 *P. pulverulenta* has always been in cultivation. It delights in a good rich loam in a damp open or half-shady position, and is seen at its best on the banks of a stream or of a pond. From the time of its introduction it has given rise to numerous forms. The first of these forms was "Mrs. R. V. Berkeley," a sterile sport with white flowers which made its appearance in the Coombe Wood Nursery of Messrs. Veitch & Sons. Many pink breaks have occurred and two were exhibited by Mr. R. V. Gifford Woolley, Lapworth, Warwickshire, under the names "Lapworth Blush" and "Lapworth Rose," the flowers of which were salmon-rose in colour. In 1911 Mr. Lawrence Johnston of Hidcote Manor, Campden, Glos., exhibited a plant which he called the "Hidcote Strain" and which had light rose flowers with a greenish-yellow centre. This plant gained an Award of Merit from the Royal Horticultural Society in 1911. But by far the finest and best known of these pink forms is the fertile "Bartley Strain" of *P. pulverulenta*, which was brought into cultivation by Mr. G. H. Dalrymple of Bartley. The better-known forms of this strain are "Lady Thursby," which is rose-pink with a yellow eye and which received an Award of Merit from the

Royal Horticultural Society in 1924; "Bartley Blush," blush pink with a light eye; "Bartley Pink," pink with a light eye, and "Hugh Dalrymple," blush pink with a dark eye.

P. pulverulenta also soon became the progenitor of beautiful hybrids, first with *P. Cockburniana* and later with *P. Bulleyana* and *P. chungensis*. The following are the better known hybrids:—

P. X Unique = *P. pulverulenta* ♀ × *P. Cockburniana* ♂. Messrs. Veitch first made this cross and the hybrid gained an Award of Merit from the Royal Horticultural Society in 1908. The flower colour is intermediate between the parents, but in size of flower and leaf the hybrid bears the mark of *P. pulverulenta*.

P. X Excelsior = *P. Cockburniana* ♀ × *P. X Unique* ♂. This plant has flowers of a rich cherry shade. Whereas *P. Cockburniana* is biennial, the hybrid is perennial. An Award of Merit was awarded to Messrs. Veitch in 1913, when they exhibited *P. X Excelsior* at the Royal Horticultural Society.

P. X Lissadell = *P. pulverulenta* × *P. Cockburniana*. Raised by Sir Josslyn Gore-Booth at Lissadell, the leaves of this hybrid are like those of *P. pulverulenta* and the flowers, which appear in May, are an inch across. Perhaps the best-known forms of the hybrid are "Red Hugh" with bright vermilion red flowers and "Aileen Aroon" with flowers of various shades of reddish orange, both of which set seed. The latter gained an Award of Merit in 1920, when exhibited by Mr. A. Prichard of Christchurch.

P. X Mrs. W. R. Lysaght = *P. X Unique* × *P. Mrs. R. V. Berkeley*. This plant was raised at Castleford, Chepstow, in 1915 by Mrs. W. R. Lysaght.

P. X Ladybird = *P. pulverulenta* × *P. Bulleyana*. Raised by Mr. W. A. Millar of Sheffield, this plant has deep rose flowers with a darker eye. It gained an Award of Merit from the Royal Horticultural Society in 1915.

P. X Inverleith = *P. Bulleyana* × *P. pulverulenta*. This is a plant with dark pink flowers which was given a Botanical Certificate in 1912, and was raised in the Royal Botanic Garden, Edinburgh.

P. X chunglenta = *P. chungensis* ♀ × *P. pulverulenta* ♂. Raised by Mr. B. O. Mulligan, and flowered for the first time in 1929, this is a hardy perennial with foliage resembling that of *P. chungensis* and with flowers as large as those of *P. pulverulenta*, at first deep bright red, fading later to salmon or coral pink, and always with a dark eye.

P. serratifolia Franch. in Bull. Soc. Bot. France, xxxii, 267 (1885), and xxxiii, 68 (1886); Pax in Engler's Bot. Jahrb., x, 219 (1889); Forbes et Hemsl. in Journ. Linn. Soc. Bot., xxvi, 42 (1889); Pax in Engler's Pflanzenr. Primulaceae, 126 (1905), pro parte; Watt in Journ. Roy. Hort. Soc. London, xxix, 315 (1904), and xxxix, 211 (1913); Balf. f., *ibid.*, xxxix, 132, 137, 166, 167, fig. 79 (1913); Forrest, *ibid.*, xli, 203 (1915); Kingdon Ward, *ibid.*, xlix, 155 (1924); *ibid.*, liv, 13, 43, 61, 71, 79, fig. 50 (1929); W. W. Sm. et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 18 (1928); Hand.-Mzt. in Symbolae Sinicae, vii, 749 (1936). *P. japonica* Forbes et Hemsl. in Journ. Linn. Soc. Bot., xxvi, 39 (1889) ?; Hemsl., *ibid.*, xxix, 313 (1893); Diels in Engler's Bot. Jahrb., xxix, 521 (1900). *P. biserrata* Forrest in Notes Roy. Bot. Gard. Edin., iv, 230, pl. xli (1908).

Delavay found this plant in 1884 in Yunnan at Tsang-chan, near to Tali, and Franchet described it in the following year in Bull. Soc. Bot. France, xxxii, p. 267. In his description Franchet states the flower colour to be yellow and compares the plant with *P. obtusifolia* Royle. However, in the following year, 1886, in Bull. Soc. Bot. France, xxxiii, p. 68, Franchet compares Delavay's type, Delavay 111, with *P. japonica* and says that the flowers are purple or violet. Meanwhile in Szechuan, Henry (H. 8879) and Pratt at Tatsienlu (P. 130), had collected plants which Hemsley and later Diels named *P. japonica.* These Szechuan plants Pax took to be the same as Delavay's Tali collection and in his monograph in Engler's Pflanzenreich in 1905 lists all three collections under *P. serratifolia*, describes the flowers as being purple and reiterates their affinity with *P. japonica.* Both Franchet and Pax were wrong in describing the flowers as purple, and Franchet was correct in saying originally that they were yellow, for on the label of a *co-type* of *Delavay* 111, which is in the Edinburgh Herbarium, there is written in Delavay's hand "Fl. jaunes."

Wilson, when collecting in Western Szechuan, sent home to Messrs. Veitch seeds which germinated and produced flowering specimens which proved to be identical with Henry 8879 and Pratt 130 from the same province and which had been named *P. japonica*. These Szechuan plants were described under the new name of *P. pulverulenta* Duthie in 1905. In that year Forrest visited the Tali Range and found what later proved to be Delavay's plant. But because Forrest's plant did not match the description of *P. serratifolia* in Pax's monograph, he himself described it in Notes Roy. Bot. Gard. Edin., iv, 230 (1908), as *P. biserrata*. Since 1905 *P. serratifolia* has been collected on numerous occasions and in areas far removed from the original locality—on the Lichiang Range, on the Mekong-Salwin divide, in N.E. Upper Burma and in S.E. Tibet.

P. serratifolia is completely efarinose. The leaves are oblong to ovate-oblong to obovate, up to 20 cm. long and 5 cm. broad, round at the apex, attenuate at the base, markedly and irregularly dentate to erose-dentate at the margin and conspicuously veined on the lower surface. To each plant there are one or two sturdy scapes which are up to 45 cm. tall and which carry a single terminal umbel of flowers, or two superposed umbels, with five to ten flowers in the umbel. These flowers have pedicels 1–2 cm. long which are slightly nodding at first and later upright and up to 3 cm. long, and which arise from the axils of linear-lanceolate bracts up to 1 cm. long. The calyx is tubular-campanulate and rather scabrid with potentially farinose glands, 5–7 mm. long, very conspicuously five-ribbed and lobed for a third to a half of its length, the lobes being ovate to elongate-triangular and hydathode-apiculate at the apex. The annulate corolla is yellow and each petal has a distinct bar of deep orange-yellow running from the mouth of the tube to the tip of the lobe. The corolla tube is usually twice as long as the calyx and in pin-eyed flowers gradually widens up from the base into the limb, whereas in thrum-eyed flowers the tube is of uniform breadth for the whole of its length until it suddenly widens out into the limb. This latter is up to 2·5 cm. in diameter and has obovate, entire or emarginate lobes. In pin-eyed flowers the style reaches the annulus, whilst the stamens are inserted just below the middle of the corolla tube. The ovoid capsule is as long as, or almost as long as, the calyx and dehisces by five longitudinal valves.

YUNNAN. At Tsang-chan, above Tali (*Delavay*, 111—*co-type*). Tali Range (*Forrest*, 1816—*type* of *P. biserrata*, 11570, 15481, 28211, 30193); Lichiang Range (F. 2974); Bei Ma Shan, Mekong-Yangtze divide (F. 13245, 13309); Mekong-Salwin divide (F. 13430, 13959, 14842, 19563); Shui loo Shan (F. 30224). Mount Fu-chuan, south-west of Wei-Hsi, Mekong-Salwin divide (*Rock*, 16960, 16986, 22743, 23262); Moting Shan (R. 23549, 23571); Yulung Shan (R. 25351). Tali Shan (*Tsai*, 53977). Mekong-Salwin divide (*Kingdon Ward*, 95).

S.E. TIBET. Salwin-Kui-Chiang divide (*Forrest*, 19066, 20873, 20993); Mekong-Salwin divide to N.W. of Tsekou Mission (F. 4100). Mount Kaakerpo, Dokerla, and Tsarong (*Rock*, 22953, 22972).

N.E. UPPER BURMA. Western flank of Chimi-li N'Maikha-Salwin divide (*Forrest*, 24573, 26879, 27273). Hpimaw Ridge (*Farrer*, 1054).

BURMA-TIBET FRONTIER. Seinghku Wang (*Kingdon Ward*, 6842).

Over its large area the plant is remarkably consistent, except for the colouring of the flowers. In this, two deviations from the type have been found, both occurring on the Burma Frontier. One has pale yellow flowers without the orange bar to the petals, and the other has the pale yellow ground colour heavily suffused with purplish rose.

P. serratifolia Franch. var. **roseo-tincta** *Forrest* in Notes Roy. Bot. Gard. Edin., xv, 254 (1927).

In July 1925 Forrest found on the Burma Frontier, at an altitude of 3500-4000 metres, a plant resembling in all ways *P. serratifolia* except in the colour of the flowers. These were pale yellow, without the golden bar and were heavily suffused with purplish rose. This flushing was so marked in the bud that the flowers then appeared to be purple. To this plant, which has not been collected since, Forrest gave the varietal name of *roseo-tincta* and his type specimen is in the Edinburgh Herbarium.

N.E. UPPER BURMA. On the western flank of the N'Maikha-Salwin divide, north of Chimi-li (*Forrest*, 26821—*type*, 27298).

P. serratifolia Franch. var. **unicolor** Forrest in Notes Roy. Bot. Gard. Edin., xv, 255 (1927).

Also on the N'Maikha-Salwin divide, in June of the same year, at an altitude of 4000 metres, Forrest discovered another colour form of *P. serratifolia*. In this plant the flowers were a soft pale yellow, without the golden bar to the petals characteristic of the species. Forrest, therefore, described it as a variety of Franchet's plant and the type specimen is in Edinburgh.

N.E. UPPER BURMA. On the western flank of the N'Maikha-Salwin divide, north of Chimi-li (*Forrest*, 26811 -*type*, 27311).

P. Smithiana Craib in Journ. Roy. Hort. Soc. London, xxxix, 190 (1913); Balf. f., *ibid.*, xxxix, 166 (1913); *ibid.*, liv, 43, 65, 71, 79 (1929); W. W. Sm. et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 17 (1928); Farrer in Gard. Chron., Ser. 3, lxviii, 20 (1920). *P. prolifera* in Bot. Mag., t. 6732 (1884), pro parte; Pax in Engler's Pflanzenr. Primulaceae, 124 (1905), pro parte.

P. Smithiana is a native of the Eastern Himalaya with a distribution extending from Central Bhutan westwards to the Chumbi Valley, but not so far as is known entering Sikkim, and with an altitudinal range of 2900 to 3500 metres. The specimens on which this species is based were for a long time confused with *P. prolifera* Wall. and even with *P. imperialis* Jungh. This difficulty is discussed under *P. imperialis* and the relationships of the species are treated under *P. helodoxa* Balf. f. The type is in the Kew Herbarium.

Oblong-lanceolate to oblanceolate the leaves are up to 20 cm. long and 5 cm. broad, round at the apex, attenuate at the base into the petiole which is more or less distinct and conspicuously winged, glabrous and efarinose on both surfaces, or with a sparse covering of yellowish farina on the lower surface, and regularly or irregularly denticulate at the margin. From this rosette of leaves arise from one to three stout scapes up to 60 cm. tall. The scapes occasionally carry a single terminal umbel of flowers, though more usually there are from two to four superposed umbels. At the nodes very pale cream or yellow farina is present and the pedicels, bracts, and calyx are markedly farinose. The bracts are linear to lanceolate, up to 1 cm. long, whilst the pedicels are usually twice as long as the bracts. The calyx is cup-shaped, up to 5 mm. long and is lobed for a third of its length, the lobes being broadly triangular and acute. Distinctly annulate and pale yellow, the corolla is usually 1–1·5 cm. in diameter across the limb, though occasionally up to 2 cm., and in most specimens the tube of the corolla is twice as long as the calyx. The lobes of the limb are oblong to oblong-obovate, and slightly emarginate. In pin-eyed flowers the stamens are inserted 2–3 mm. from the base of the corolla tube, whilst the style reaches the annulus. The globular capsule is as long as or slightly longer than the calyx and dehisces by five valves.

TIBET. Chumbi valley below Rinchhingong (*E. H. Walsh*, 157). Chumbi valley, Lingmuthang (*Rohmoo Lepcha*, 64). Chumbi (*Dungboo*). Chumbi (*Cave*). Chumbi (*Cooper*, 190, 651). Chumbi valley (*Ludlow and Sherriff*, 17).

BHUTAN. On the Yuto La, Tongsa (*Cooper*, 2283); Phajuding, Timpu (C. 2934); on the Duké La, Timpu (C. 3209); Paro (C. 3878); Tongsa Djong (C. 3983); Ohra, Punthang (C. 4744). Longte Chu (*Ludlow and Sherriff*, 3250); on the Yuto La (*Ludlow and Sherriff*, 3465).

This well-known handsome perennial species requires to be planted in a sunny spot in the open, in good rich fibrous loam. When in growth it must be well supplied with water.

P. stenodonta Balf. f. MS., descript. W. W. Sm. et Fletcher, *supra*, p. 120. *P. angustidens* (Franch.) Pax in Engler's Pflanzenr. Primulaceae, 128 (1905), pro parte. *P. Wilsoni* Dunn; Balf. f. in Journ. Roy. Hort. Soc. London, xxxix, 131, 139, 166 (1913), pro parte. *P. Poissonii* Franch. subsp. *angustidens* (Franch.) Pax ex W. W. Sm. et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 17 (1928), and in Journ. Roy. Hort. Soc. London, liv. 43 (1929). *P. japonica* A. Gray var. *angustidens* Franch. in Bull. Soc. Bot. France, xxxiii, 68 (1886); Pax in Engler's Bot. Jahrb., x, 218 (1889); Forbes et Hemsl. in Journ. Linn. Soc. Bot., xxvi, 39 (1889).

According to Pax's citation of specimens under *P. angustidens* (Franch.) Pax in Engler's Pflanzenr. Primulaceae, 128 (1905), his species is based on two different collections, Delavay 214 bis and Henry 12121, 12121A, and 12121B. These collections are discussed under *P. Wilsoni* Dunn. It is evident from the figure and description in the Pflanzenreich that Pax's diagnosis of *P. angustidens* is based entirely on the

Henry specimens and not on Delavay's plant, which he apparently never saw. No claim for priority can be placed on Franchet's varietal name (*P. japonica* A. Gray var. *angustidens* Franch.), and Dunn's description of *P. Wilsoni* was published three years before the date of Pax's monograph. It does not seem to us that he was in any way entitled to reduce Dunn's species to *P. angustidens.* Had he confined his description to the Delavay plants, then the name *P. angustidens* Pax could have stood. But then he never saw these plants and so could not describe them. In his figure and description, however, he makes it clear that his *P. angustidens*, as he understood it, is founded on the Henry sheets. Consequently *P. angustidens* Pax is a synonym of *P. Wilsoni* Dunn, and the first correct translation of Delavay's plant to specific rank was made by Sir Isaac Bayley Balfour when he called it *P. stenodonta* Balf. f., but he did not publish this name. Dunn in his description of *P. Wilsoni* referred also to the Delavay sheets as representing the same thing as the Henry sheets and the living plant grown from Wilson's seed. It is, however, quite evident that Dunn in his description of *P. Wilsoni* did not make use of the Delavay specimens and his description is in no way applicable to them.

A difficulty arises as to the correct locality for *P. stenodonta*, but that is discussed under *P. Wilsoni* Dunn.

P. stenodonta is in accord with *P. Wilsoni* and its allies in being completely efarinose, but does not agree so well in its foliage characters and in the structure of the bracts, calyx, and corolla. Rather does it approach *P. Beesiana*, which, however, is markedly farinose. A deciding factor would be the character of the fruit, which is not yet available. We hazard the suggestion that it will be globose as in the majority of the members of the section, and not ovoid to oblong as in *P. Wilsoni* and its allies.

The leaves of Delavay's plant are oblong to oblanceolate to obovate, up to 15 cm. long and 4 cm. broad, round at the apex, strongly attenuate at the base into the short broadly winged petiole, regularly denticulate at the margin, glabrous on both surfaces, but with a thin covering of potentially farinose glands on the lower surface. Rising to a height of 30 cm., the efarinose scape carries two or three superposed tiers of reddish-violet flowers. These flowers are carried on pedicels which are up to 1·5 cm. long and arise from the axils of linear bracts which are as long as the pedicels. The calyx is tubular-campanulate, 5–6 mm. long and is divided to the middle into lanceolate, long-acuminate teeth. The corolla tube is two to three times as long as the calyx, whilst the distinctly annulate limb is more or less patent and is at most 1·5 cm. in diameter. In thrum-eyed flowers the stamens are inserted slightly below the annulus and the style is as long as the calyx or occasionally slightly longer. Nothing is known of the capsule. The type specimen, Delavay 214 bis, is in the Edinburgh Herbarium.

N.E. YUNNAN. Ou-tchai, near to Ta-kouan (*Delavay*, 214 bis—*type*, 314 bis). At Tse-tchou-pa and at Tsang-fang (*Maire*).

Only further material from the N.E. corner of Yunnan can solve the problem of this species. It has never been in cultivation.

P. Wilsoni Dunn in Gard. Chron., Ser. 3, xxxi, 413 (1902), pro parte; *ibid.*, lxxxiv, 469 (1928); *ibid.*, civ, 176 (1938); Balf. f. in Journ. Roy. Hort. Soc. London, xxxix, 131, 135, 138, 159, 166, 167 (1913). *P. Poissonii* Franch. subsp. *Wilsoni* (Dunn) W. W. Sm. et Forrest in Journ. Roy. Hort. Soc. London, liv, 43 (1929), and in Notes Roy. Bot. Gard. Edin., xvi, 17 (1928). *P. angustidens* (Franch.) Pax in Engler's Pflanzenr. Primulaceae, 128, fig. 36 (1905), pro parte; Balf. f. in Gard. Chron., Ser. 3, lvi, 142 (1914). *P. glycyosma* Petitm. in Bull. Herb. Boiss., Sér. 2, viii, 364 (1908). *P. oblanceolata* Balf. f. in Gard. Chron., Ser. 3, lvi, 142 (1914).

Dunn founded his species on the following collections: Delavay 214 bis and 314 bis which had been received from Paris under the name of *P. japonica*, and Henry 12121 and 12121A, as well as on plants which had been raised from seed collected by Wilson for Messrs. Veitch & Sons. Pax, in his monograph in Engler's Pflanzenreich in 1905, under the heading of *P. angustidens* (Franch.) Pax, quotes Delavay 214 bis and Henry 12121, 12121A, and 12121B as the collections upon which he has founded his species. He thus omits Delavay 314 bis, which was part of Dunn's original *P. Wilsoni*, and includes a collection not quoted by Dunn, Henry 12121B. Both Dunn and Pax were in error in considering the collections of Delavay and Henry to represent one and the same species. In the first place, there is a marked geographical distinction between the two sets of collections. Those of Henry were taken from the mountains of Szemao in Southern Yunnan. Of Delavay's locality there would appear to be some doubt. In the Edinburgh Herbarium there is a sheet of Delavay 314 bis, the label of which is written by Delavay and the locality is given as "Ou-tchai." There is also a sheet of Delavay 214 bis, the label of which is also written in Delavay's hand, and here the locality is "Ou-tchai près de Ta-Kouan." Now Ta-Kouan is in the extreme N.E. of Yunnan. However, when Franchet described Delavay's specimens in Bull. Soc. Bot. France, xxxiii, 68 (1886), he states the locality as "Ou-tchai près de Tali." This locality is also given by Pax and it would seem that in this both authors are in error, especially so as Maire also collected specimens which are equivalent to Delavay's at Tse-tchou-pa and at Tsang-fang, which localities are also in Eastern Yunnan. In addition to this geographical divergence between the collections of Delavay and of Henry, there are also important morphological distinctions, for Henry's specimens have short triangular calyx lobes and bracts shorter than the pedicels, whereas Delavay's specimens have lanceolate and long-acuminate calyx lobes and bracts as long as the pedicels. Thus only *Henry* 12121, 12121A, 12121B represent true *P. Wilsoni*; Delavay 214 bis and 314 bis represent what was at first known as *P. japonica* A. Gray var. *angustidens* Franch. and what was in part later known as *P. angustidens* (Franch.) Pax. As this species stands in Pax's monograph, it is a chimaera of *P. Wilsoni* and *P. angustidens*, and fig. 36 represents in the main *P. Wilsoni*, though it is a poor representation of that species.*

The three Henry collections hardly at first sight appear to represent the same species, for Henry 12121B has much longer leaves with larger teeth than have the other two. This was one of the characters used by Sir Isaac Bayley Balfour in 1914, when he separated this collection from the others as a new species to which he gave the name *P. oblanceolata*. Sir Isaac maintained that the limb of the corolla of his plant was flat, after the style of *P. Poissonii*. With this the writers cannot agree, for in an examination of all three Henry specimens, the corolla limb of Henry 12121B is no more patent than that of the other two, and is certainly not comparable to the large flat corolla limb of *P. Poissonii*. However, in spite of this, Sir Isaac at that time seemed justified in separating his plant from the others on foliage characters alone. But since then *P. Wilsoni* has become far better known both in the garden and in the herbarium, and its range of leaf variation is quite large enough to forbid *P. oblanceolata* being retained as a distinct species.

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* Actually the correct name for the species based on the Delavay plants is not *P. angustidens* but *P. stenodonta* Balf. f.. This point is discussed under the latter species.

P. Wilsoni has less glaucous leaves than *P. Poissonii*, but like that species retains them all through the winter. They are oblanceolate, up to 20 cm. long and 5 cm. broad, round at the apex, strongly tapering into the petiole which is conspicuously winged at the base, finely denticulate at the margin, which tends to be slightly recurved, and thinly covered on the lower surface with potentially farinose glands. The stout scape is 90 cm. or more in height and carries three to six tiers of flowers. These are borne on pedicels up to 2 cm. long which are supported by linear bracts up to 1 cm. long. Campanulate, 5–6 mm. long and usually lacking the red striae of *P. Poissonii*, the calyx is lobed for a third to a half of its length, the lobes being triangular-ovate and acute or obtuse. The purple annulate corollas have a tube two and a half to three times as long as the calyx and a limb usually at most 1·5 cm. in diameter, and concave, for the lobes never become completely patent. The lobes are almost rotund, usually slightly longer than broad, faintly emarginate, sometimes crenulate, or entire. In pin-eyed flowers the style extends half-way or two-thirds of the way up the corolla tube, and the stamens, with anthers 1 mm. long, are inserted at the base of the tube. The globose ovary is 1·5 mm. in diameter, whilst the ovoid to oblong capsule is decidedly longer than the calyx.

YUNNAN. Szemao mountains (*Henry*, 12121—*co-type*, 12121A, 12121B (*type* of *P. oblanceolata* Balf. f.); Yunnanfu (*Ducloux*, 569). Yung-fen Hsien (*Tsai*, 52819, 52866); Chao-tung Hsien (T. 50916); Lan-ping Hsien (T. 53715). Pai-ching (*McLaren*, 3, 17); Yao-chou (McL. 20); Kari Pass, Mekong-Yangtze divide (*Forrest*, 13150).

SZECHUAN. On Mount Siga (*Rock*, 24387); Mount Siga, west and overlooking the Yalung (R. 23875); banks of Yetsi Valley (R. 23884); west of Mount Mitzuga, Muli (R. 24519, 24521); Mount Mitzuga, Muli territory (R. 24032, 24036); mountains of Kulu (R. 18037); north of Chiu-Lung-Hsien, in Minya country, south-west of Tatsienlu (R. 17756); mountains between the Litang and Galung rivers, between Muli Gomba and Baurong and Wa-Erh-Dje (R. 16620); watershed of the Shou-Chu River and Shou-Chu Valley (R. 16267). Sikang, Tatsienlu (*Harry Smith*, 10297). Mountains west of Muli (*Forrest*, 22104); Jen Ching, six days north of Muli (F. 30272); Muli mountains (F. 16791, 17002). Tatsienlu (*Cunningham*, 448).

We must here put in the caveat that although it is easy to distinguish between *P. Wilsoni* and *P. Poissonii* in the living state, it is quite another matter to determine herbarium specimens unless the quality of the dried material is satisfactory. Consequently the citations of collector's numbers under these two species are given in some cases with considerable reserve. The geographical record seems to indicate that both species occur throughout Szechuan and Yunnan and frequently in the same area.

OBITUARY NOTICE.

John Rutherford Hill.

In Mr. Rutherford Hill the Botanical Society of Edinburgh has lost one of its oldest members, and one who, for over fifty years, has been closely associated with all its interests. He was born in 1857, near Windermere, of Scottish parentage. His life-work was in pharmacy, and his outstanding abilities gained him early promotion to responsible posts. He became a recognised University lecturer in Pharmacy and Materia Medica in the Edinburgh School of Medicine and later Principal of the School of Pharmacy. In 1886 he was appointed Resident Secretary in Scotland of the Pharmaceutical Society of Great Britain and spent the next fifty years in its service. His outstanding ability as an administrator was combined with unceasing activity in research. For an adequate appreciation of his position in his chosen line of work, reference should be made to the Pharmaceutical Journal of 26th July 1941.

Amid his many interests it was rarely that Mr. Rutherford Hill missed any of the meetings of the Botanical Society. He became a Fellow in April 1886, served many years on the Council, was President in 1906–1908 and again in 1929–1931. His own special researches were published in the appropriate Journals and he contributed to our Transactions only occasional short notes on botanical subjects, apart from the interesting review in his Presidential Address of 1908. But his own field of work was the source of a long series of exhibits at our meetings, all the more welcome for the clear and concise descriptions which accompanied them. To the Fellows of the Society Mr. Hill remains a memorable and notable figure—for his wise counsel, for his unflagging zeal, for his shrewd comments in debate, and above all for the geniality which pervaded the whole man.

In 1936 the O.B.E. was conferred upon him, just before his retirement at the end of September 1936 from the post he had occupied with great distinction for half a century. He died at Balerno, Midlothian, on 17th July 1941, in his eighty-fifth year.

W. W. S.

TRANSACTIONS

OF THE

BOTANICAL SOCIETY OF EDINBURGH

SESSION CVI

Notes on Lichens in the Herbarium of the Royal Botanic Garden, Edinburgh. III. By W. Watson, D.Sc.

(Read 19th February 1942.)

After my second lot of notes in these Transactions was published in 1939, Mr. Young, who was in charge of the lichens in the herbarium, discovered some further unnamed specimens, most of which were collected about 1856 by the famous Scottish lichenologist Lauder Lindsay. These specimens numbered about 300 and consisted mostly of crustaceous lichens, 160 of which were collected in Scotland in the counties of Perth, Argyll, Inverness, and the islands of Skye, Lewis, and the Shetlands. About 90 were collected from the neighbourhood of Ingleborough, W. Yorkshire, partly by Carrington in 1857 and partly by Lindsay in 1859. Other material consisted of various lichens collected by Moore, Gilchrist, Richardson, Hardy, Sadler, W. Johnson, and others. Their examination usually entailed the use of the microscope, and this and other circumstances has retarded their determination. No doubt the necessity of microscopic examination was the main factor in their lack of determination by Lindsay, suitable opportunity and sufficient time were not available for the large amount of material accumulated. Another factor was sometimes due to the fact that no lichen agreeing with the specimen had been described, *e.g.* an unnamed specimen collected from Lochnagar in 1856 is *Lecidea commaculans* which was not described till 1868. Lindsay also collected *Euopsis pulvinata* from the summit of Ben Lawers in 1851. The plant had been described previously, but was not known to be British, and it was not till 1871 that Stirton collected the first recorded Scottish material in the same locality. Some other reasons why this prince of Scottish lichenologists did not name the plants may be deduced from the notes given under their respective names. Some of Hardy's puzzles were apparently sent to Lindsay and were undetermined. Some of them were off-type specimens, but after careful examination it was not considered necessary to create new species as they could be placed within the ambits of those already existing.

Many interesting facts, similar to those previously given, are mentioned in the notes on the different species. The following are new to the British Isles: *Letharia arenaria*, *Lecidea assimilata*, *L. subcinerascens*, *L. plumbea* (?), *L. plana* f. *ecrustacea*, *L. lapicida* f. *ochromeliza*, *L. Kochiana* f. *fuscescens*, *Pertusaria constricta*, *Thalloidima tabacinum*, *Cladonia pyxidata* v. *chlorophaea* f. *mesotheka*, *Verrucaria fusconigrescens*, *Thelidium acrotellum* and *T. papulare* f. *arenarium*. The following are new to Scotland: *Parmelia comparata*, *Lecidea aggregatula*, *L. cinereoatra*, *L. sympathetica*, *L. asperella*, *L. crustulata* f. *ferruginea*, *L. fuscoatra* f. *roridella*, *Acarospora scyphulifera*, *Pertusaria coccodes*, *Rhizocarpon rubescens*, *R. obscuratum* v. *roridulum*, *Cladonia crispata* v. *infundibulifera*, *Stereocaulon subcoralloides*, *Peltigera rufescens* v. *lepidophora*, *Allarthonia patellulata*, *Chaenotheca trabinella*, *Verrucaria cyanea* and *V. scotina*. Some species which are very rare and only recorded previously from one or two localities are: *Lecanora fugiens* v. *chlorophaeoides*, *Biatora filamentosa*, *B. albohyalina*, *B. valentior*, *Lecidea commaculans*, *L. contortula*, *L. subgyratula*, *L. mesotropiza*, *L. mesotropoides*, *L. xanthococca*, *L. athroocarpa*, *Thalloidima squalescens*, *Bilimbia leucoblephara*, and *Pannaria Hookeri*.

All the specimens collected were examined, but unless they were of sufficient interest their names have been omitted from the following list. When no collector's name is given the specimen may be assumed to have been collected by Lauder Lindsay. The numbers refer to the botanical vice-counties in which the lichens were collected, and the addition of an asterisk indicates that the plant was not known to have been recorded for the vice-county. The specific names usually follow those given in A. L. Smith's Monographs, but in some cases a name which has a priority claim is also given.

During the last few years a number of lichens from Scotland have been collected by myself, or have reached me from other sources for confirmation or determination. When these are vice-county records I have noted them in the list.

The following abbreviations are used: C indicates the use of hypochlorite of lime solution, K that of caustic potash solution, KC that of caustic potash followed by calcium hypochlorite. What follows indicates the coloration given, a negative sign indicating no coloration. Plants of my own collecting are indicated by W. W. The names of other collectors are abbreviated as follows: D. A. J. for D. A. Jones, E. C. W. for E. C. Wallace, I. M. L. for I. M. Lamb, H. H. K. for H. H. Knight, L. B. T. for L. B. C. Trotter, U. D. for Ursula Duncan.

My thanks are due to Mr. Young for his assistance in the arrangement of the specimens in convenient groups for examination and for giving the vice-comital numbers of the localities where they were collected.

List of Lichens.

Usnea ceratina Ach. Iona (104*) L. B. T.

U. dasypoga (Ach.) Nyl. Near Moffat (72) McAndrew as *U. barbula* var. *pendula*. W. Linton (78*) as above. McIntyre's specimen from Ben Lawers labelled *U. dasypoga* is *Alectoria jubata* var. *subcana*.

U. comosa (Ach.) Roehl. = *U. hirsutula* Stirt. Drumossie (96*) and Golspie (107*) E. C. W.

U. mollis Stirt. Glen Roy, etc. (97*) W. W.

Alectoria jubata v. *chalybeiformis* (L.) Ach. Slochd Mor, Ben Avon (94*) E. C. W.

A. nigricans (Ach.) Nyl. Durness (108*) E. C. W.

Letharia arenaria (Retz.) Harm. A plant collected on the ground at Shrobnall Marl Pit (39) in 1854 has a ramalinoid appearance and Mr. Lamb thinks that it may be the above. It agrees fairly well with the description though the ends of the lobes are often not white-sorediate and never distinctly so, and the cortex does not give a yellow coloration with K. It has not been recorded from the British Isles.

Parmelia perlata (Huds.) auct. plur., Stoer (108*) E. C. W.; var. *ciliata* (DC.) Schaer. Raasay (104*) U. D., Stoer (108*) E. C. W. It may be noted that *P. perforata* of Crombie's Monograph (given as *P. cetrata* in A. L. Smith's Monograph) is not the Acharian plant, but *P. reticulata* Tayl. *P. perforata* Ach. belongs to the *perlata* group in which the rhizinae are absent from a marginal zone of the under surface of the thallus, though similar structures may be present as cilia on the extreme edge. *P. reticulata* Tayl. belongs to the *saxatilis* group in which the rhizinae occur all over the under surface and cilia are usually absent on the edges.

P. fuliginosa Nyl. Lochmaben (72*) Richardson as *P. olivacea* in Herb. Oxford.

P. Delisei (Dub.) Nyl. Glen Brittle, Skye (104*) U. D.

P. conspersa (Ehrh.) Ach. On dyke near Broomlands, Moffat (72*), belongs to form *isidiata* Leight.

P. comparata Nyl. On trees in wood between Dalmahoy and Currie (83*), J. M. Lindsay (1856). This is very nearly akin to *P. laevigata* Ach., but the medulla as well as cortex becomes yellow with K.

P. revoluta var. *rugosa* (Tayl.) Cromb. Caherhoyne, Co. Cork, Carroll (1858). New for Co. Cork.

P. saxatilis (L.) Ach. Golspie (107*) and Stoer (108*) E. C. W.; Isle of Barra (110*), *det.* I. M. L.: form *furfuracea* Schaer., near Stoer (108*) E. C. W.; var. *laevis* Nyl., Golspie (107*) E. C. W.

P. sulcata Tayl., Slochd Mor, Ben Avon (94*), and Glen Troligill (108*), E. C. W.; form *rubescens* (Harm.) B. de Lesd., Stornoway (110*).

P. omphalodes (L.) Ach. In herb. Greville there is a narrowly laciniate and palish form collected from Loch Etive by Trevelyan in 1831. Iona, with form *panniformis* Ach. (103*) L. B. T.

P. pubescens (L.) Wain. Slochd Mor, Ben Avon (94*) E. C. W.

Hypogymnia physodes form *labrosa* (Ach.) Wats., Dumfries (72*) ex herb. Greville; var. *platyphylla* (Ach.) Wats., Dryburgh (81*) D. A. J.

H. alpicola (Th. Fr.). This is *Parmelia alpicola* Th. Fr. Vainio uses the name *P. atrofusca* (Schaer.) Crombie, but *alpicola* was used as a specific name prior to such usage for *atrofusca*. Slochd Mor (94*) E. C. W.; near Aviemore (96*) D. A. J.

Platysma lacunosum (Ach.) Nyl. Hallaig, Raasay (104*) U. D.

P. glaucum (L.) Nyl. A dark form was collected by Mr. Wallace from Clach-a-Cleirich (92) and typical material from Slochd Mor, Ben Avon (94*).

P. saepincolum Hoff. A number of specimens referred to this in the herbarium were sent for examination. As expected, they were all referable to the commoner *P. chlorophyllum* (Humb.) Wats. Penzance (1) Waterfall and Curnow; Stokesley and Ayton (62), Mudd; Penmanshiel (81*) Hardy; Humbie Wood, McAndrew, and Tentsmuir (85) E. M. Holmes and W. Smith; Garrynahine (110). Apparently the only specimen of *P.*

saepincolum in the herbarium is that collected by Lindsay from Dalwhinnie (96).

Cetraria islandica form *platyna* Fr. Siochd Mor (94*) E. C. W.

C. aculeata (Schreb.) Fr. Stoer (108*) E. C. W.

Squamaria muralis (Schreb.) Elenk. Fort William (97*) W. W.; var. *albomarginata* (Nyl.) Meres., Balerno (83*) U. D.

S. cartilaginea (Ach.) DC. A specimen collected on peaty soil of Blaeberry Hill (89*) seems to be a small form of this, but the material is too scanty for the determination to be quite definite. A. L. Smith uses *Achariana* as the specific name for this because *cartilagineus*, as used by Lightfoot in 1777, refers to the plant usually given as *crassa*. Lightfoot's name has priority as Hudson's *Lichen crassus* was not used till 1778. Miss Smith's change is justifiable from priority, but very confusing as the use of *crassa* for Hudson's plant had been generally accepted for over a century.

S. gelida (L.) Hook. Glen Nevis (97*) W. W.

S. circinata (Pers.) Hook., = *S. radiosa* (Hoff.) Poetsch. Walls about Oxford (23). This specimen has a supplementary reaction with K and therefore belongs to the form or variety *subcircinata*. This appears to be the usual form in our islands.

Lecanora galactina var. *dispersa* Ach. Falls of Foyers (96*).

L. umbrina Mass. Portree, Skye (104*).

L. Hageni Ach. Golspie (107*) E. C. W.

L. campestris (Schaer.) Hue. Fort William (97*) W. W.

L. coilocarpa (Ach.) Nyl., Dulaw Burn (81*) Hardy; form *pulicaris* (Pers.) Cromb., on wood, Almond Bridge (88).

L. pallida Schaer. and *L. carpinea* (L.) Wain. Both of these were collected by Richardson in Kirkcudbright (73*) and are in herb. Oxford.

L. rupicola (L.) Zahl. In herb. Dickson without indication of locality. It is marked *Lichen rupicola*, and it is interesting to find that Dickson used this specific name which Zahlbruckner has recently considered to have priority to either *glaucoma* or *sordida*, the names used in the Brit. Mus. Monographs.

L. atra (Huds.) Ach. Colvend (73*), Richardson in herb. Oxford. A plant collected by Moore from County Kerry and labelled "Pertusaria" seems to belong to a very rugose-thallused form, but the apothecia are too ill-developed for definite determination.

L. polytropa Schaer. Specimens from 85, 88, 89 and 92 were present. An abnormal form of a crustaceous lichen from Horn Head

(I. 35) collected by Pr. Dickie may be a large state of the form *alpigena* (Ach.) Leight. As it is without spores a definite determination is not possible.

L. symmictera Nyl., on stems of heather, Collingham Moor (81*) Hardy; var. *aitema* (Ach.) Nyl., is also present (81*); var. *trabalis* Nyl., Stromness (111*).

L. symmicta Ach. Fort William (97*) W. W.

L. conizaeoides Cromb. Collected by R. Burn near Holytown (77*).

L. expallens (Pers.) Ach. Golspie (107*) E. C. W.

L. fugiens v. *chlorophaeoides* (Nyl.) A. L. Sm. Kyles of Bute, probably from the mainland (98*).

Ochrolechia parella (L.) Arn. A freak state from Gunnerton Crags (67) Johnson.

O. pallescens (L.) Mass. Assynt (108*) H. H. K.

Aspicilia caesiocinerea (Nyl.) Arn. Top of Norman Law, Newburgh (85*).

A. lacustris (With.) Th. Fr. Near Quirang (104*).

A. cinereorufescens (Ach.) Krb. In my last lot of notes (1939) reference was made to some plants which seemed to agree with this species though the apothecia were reddish and some other differences occurred. Some suspicion that they really belonged to Aspicilia was entertained, and further examination has convinced me that they cannot be referred to Aspicilia despite the aspicilioid appearance of the apothecia. A proper dark margin without algal cells is present, the hypothecium is darkish in a moderately thin section and there are no algal cells below it. They must therefore be placed in the genus Lecidea. That from Ben Ledi agrees with *L. athroocarpa* Ach. as described by Th. Fries in Lich. Scan. and Vainio in his Lich. Fenn. The apothecia are, in these works, described as innate or immersed, but are given as adnate in A. L. Sm. Brit. Lichens and in Leight. Lich. Flora. They are certainly innate in both the Ben Ledi and the Garrynahine specimens. The Garrynahine specimen, because of the smaller spores and the bluish colour of the paraphysial apices, agrees better with *L. subcinerascens* Nyl. This is new to Britain. A specimen collected from v.c. 47 also belongs to it.

Psora ostreata Hoff. Linn of Dee (92*) D. A. J.

P. Friesii (Ach.) Hellb. Ethie wood, Arbroath (90*) U. D.

P. decipiens Hook. Kirkcudbright (73*), *sec.* Richardson in herb. Oxford.

Biatora phaeops (Nyl.) Arn. Falls of Foyers (96*). Though asci and spores are not shown the general appearance is agreeable.

B. flexuosa Fr. Kinnoull Hill and Balthayock (89*).

B. granulosa var. *escharoides* (Ehrh.) Rehm. On turf, Swanston Hill (83*) Linton. W. Lomond Hill (85*); var. *viridula* (Larb.) Clapham (64*) Carrington.

B. viridescens (Schrad.) Mann. Balthayock Wood (89*). One of the specimens has become browner in the herbarium and so suggests *fuliginea*, but the thallus gives a red coloration with KC. Both *viridescens* and *fuliginea* vary in colour in the field according to conditions of light and moisture.

B. coarctata var. *glebulosa* (Sm.) Arn. Sidlaw Hills (90*) U. D. This belongs to the form *microphyllina* Fr.

B. gelatinosa (Flk.) Fr. In a wood two miles from Peebles (78*) Sadler, 1857.

B. valentior (Nyl.) Wats. On side of rivulet, Bushiel Dean (81*) Hardy.

B. albohyalina (Nyl.) Bag. et Car. Bushiel Dean (81*) Hardy.

B. fuscorubens Nyl. Penmanshiel (81*) Hardy. Stromness (111*).

B. atrofusa Flot. L. Coruisk, Skye (104*), with form *congesta* Cromb. Co. Wicklow (I. 20) Moore.

B. filamentosa (Stirt.). Dumfries (72*). Spores are ill-developed and I have been unable to confirm the determination with a well-authenticated specimen.

Lecidea protrusa Fr. Bushiel Dean (81*) Hardy. Kilcully (I. 5) Carroll.

L. parasema Ach. Kirkcudbright (73*) with f. *limitata* Ach. In herb. Oxford *leg.* Richardson.

L. latypea Ach. Clapham and summit of Ingleborough (64*) Carrington. Edinburgh (83*) Sadler. Montrose (90*) U. D. Coast of Antrim (I. 39*) Moore.

L. goniophila (Flk.) Schaer. A number of specimens from different counties and varying in the depth of colour shown by the hypothecium. A specimen from Stronsay (111) is, in some respects, near to *L. assimilis* Th. Fr., but paraphyses are not conglutinate.

L. leucophaea (Flk.) Nyl. Stronsay (111*). In this specimen the areolae are flatter and darker than usual; the apothecia show the usual reddish or brownish tint when moistened.

L. leucophaeiza Nyl. Birnam Hill (88*), Glen Nevis (97*) W. W. These specimens are similar to *L. leucophaea*, but K gives a yellow colour to the thallus. Nylander states that the thecae alone are coloured blue by iodine, and this may be true when very thin sections are used. In a moderately thin section the whole hymenium becomes blue, but when crushed the blue coloration is chiefly shown in the asci or the paraphyses immediately around them, the paraphyses further away being colourless or merely yellowed. The aggregation of the amyloid material in the asci and the neighbouring paraphyses gives some foundation to Nylander's assertion. Certainly the main parts to be affected by iodine are the evenly thickened walls of the asci.

L. *lapicida* form *ochromeliza* (Nyl.) Harm. As this form has not been hitherto recorded from the British Isles, though it has been previously noted by me from v.c. 48 and 49, its distinguishing characters as given by Vainio are appended, thallus ± well-developed, ochraceous altogether or in patches, hypothecium in lower portion brownish to dark brown. On basaltic boulders, top of Norman Law (85*). The internal structure of the apothecia was not too distinct, but this was the case with all the six packets of Lecideas from this locality, the asci being mostly immature and the spores ill-developed.

L. *pantherina* var. *lactea* (Flk.) Vain. W. Lomond Hill (85*). Ben Nevis (97*) W. W.

L. *lulensis* Hellb. Bushiel Dean (81*) Hardy. The red supplementary coloration with K is not so distinct as usual, being paler or dirtier red, but such supplementary reactions are often uncertain or indefinite. It may go under form *leucophaeoides* Nyl.) Vain., in which the thallus is whitish and the epithecium reddish or brownish. A specimen from Birnam Hill (88) may go under f. *cinerella* Vain., Lich. Fenn., iv, 200. "Thallus cinereus. Epithecium glaucescens et fuscescens in eodem apothecio quoque."

L. *subkochiana* Cromb. Paraphyses dark at the ± thickened and coherent apices, otherwise similar to L. *pantherina* with a brown hypothecium. Between Spittal of Glenshee and Braemar, and not recorded for either 89 or 92.

L. *aggregatula* Nyl. A specimen from greywacke, Bushiel Dean (81*) Hardy, is nearest to this species.

L. *mesotropiza* Nyl. Braemar and Lochnagar (92*), Sciur-na-Gillean (104*).

L. *mesotropoides* Nyl. On a stone wall at the foot of W. Lomond Hill (85*). The stone was probably derived from a higher altitude. The specimen is rather too scrappy for quite definite determination.

L. lithophila Ach. Clapham (64*) Carrington. Foot and also summit of W. Lomond Hill and Norman Law (85*). Two specimens from Kinnoull Hill (89) have the hypothallus little distinct, the thallus slightly yellowed by K and its spores are slightly relatively broader than usual. Form *ochracea* (Ach.) Nyl. Clapham (64*) Carrington.

L. plana (Lahm) Nyl. Clapham (64*) Carr. Summit of Cairngorm (92*, 94*). Most of the specimens from the summit of Cairngorm and one from the summit of Lochnagar (92*) belong to the form *ecrustacea* Vain., in which the thallus is almost absent, as in so many other species from the summits of such high mountains. Vainio in Lich. Fenn. uses *enteromorpha* as the specific name, but, according to his own citations, *plana* was the first name used specifically.

L. alpestris Somm., summit of Ben Lawers (88); v. *brachyspora* Lamb., also present and also on the summit of Ben Macdhui (92*, 94*).

L. arctica Somm. Clova (90*) U. D.

L. assimilata Nyl. Summit of Ben Lawers, 1856. There is some admixture of *L. arctica* and *L. alpestris*, but the main gatherings are of *L. assimilata*. Two specimens mounted in the same box belong to different species, showing that even the keen-eyed Lauder Lindsay could not distinguish between them. One is *L. alpestris* with pale or discoloured hypothecium, the other is *L. assimilata* with apothecia more confluent, narrower hymenium (50 μ instead of 75 μ) coloured blue by iodine, but more quickly becoming sordid-red, paraphyses more coherent after the addition of K, hypothecium darker and redder, reddened by K instead of pallid brown yellowed by K. In both species nitric acid gives a purplish tint to the epithecium. It is quite a recent addition to Scottish lichens, as it is during the last three years that Mr. Lamb considered a specimen collected from above Lochan Bhuide at an altitude of 3870 feet on Ben Macdhui to be *assimilata*.

L. griseoatra (Hoff.) Schaer. Two specimens from Birnam Hill (88) are referable here. In both the reddish colour of the thallus with KC was difficult to obtain, but a distinct red was shown when freshly made hypochlorite was used. There is no reaction with iodine, though one is indicated in A. L. Sm. Monograph. In one specimen the blue material of the paraphyses was not merely at their apices but was also shown as bluish-violet grains or even stripes lower down mimicking those shown in *sanguineoatra*.

In both the algal cells of the thallus are small, 8–12 μ, rarely larger, the slender discrete paraphyses are apically shortly septate and very slightly clavate, coloured violet-red by nitric acid, but little changed by K, asci longly clavato-cylindrical, spores 9–12 × 4 5 μ. *Aspicilia cambusiana* seems near but differs in verrucoso-areolate yellower and thicker thallus, larger gonidia and paraphysial cells longer than broad near the apex and clavate. Vainio in Lich. Fenn. contends that the specific name *griseoatra* is unacceptable and replaces it by *atrocinerea*. Even if his arguments are sound he replaces the name *tenebrosa* which had been in use for a long time (it is used by Krb., Nyl., Th. Fr., Mudd, Leight., Crombie, Lindau, etc.) by a name whose specific use is apparently later.

L. rivulosa Ach. On compact felspar, Pentland Hills (83*). It is decidedly *rivulosa* owing to pale hypothecium, dark-brown paraphysial apices, asci thick-walled above and deep blue with iodine and spores of right shape and size, but thallus with K is certainly yellowish and even slightly reddish. A plant from Birnam Hill (88) approaches form *lobatula* Nyl. The thallus is thick, cracked-areolate with unevenly convex areolae, but the apothecia are rarely up to 2 mm. diam., or with distinctly lobate margins.

L. kochiana f. *fuscescens* Magn. Morrone (92*). Thallus fuscescent, with areolae paler and often much larger around the apothecia.

L. lygaea Ach. Kinlochleven (97*) W. W.

L. asperella Stirt. Summit of Lochnagar (92*). Departs in some respects from the descriptions in Leighton's Lich. Fl., ed. 3, p. 283, and A. L. Smith's Monograph, 1926, p. 75, the thallus not being granular or furfuraceous, though in some places it is "thickish cracked-areolate," the apices of paraphyses are not always blue but usually darkish brown, and do not give a distinct violet-purple coloration with nitric acid, though there is some violet tint given to the brown. It agrees in the dark thallus, small apothecia with colourless hypothecium subtended by a brownish-black excipulum, spores colourless, simple, 7–10 × 4–5 μ.

L. athroocarpa Ach. Ben Ledi (87*). See *Aspicilia cinereorufescens.*

L. subcinerascens Nyl. Garrynahine (110*). See *Aspicilia cinereorufescens.*

L. contortula Stirt. Storr Rock, Skye (104*). Owing to the gyrosoplicate apothecia this is put with Stirton's species, though the thallus is thinner and the apothecia smaller. New for Scotland.

L. consentiens Nyl. Sligachan (104*) with form *circumsissa* Nyl.

L. panaeola Ach. Kinlochleven (97*) W. W., is form *subconsentiens* Leight.

L. subgyratula Nyl. W. Yorkshire (64*) Carrington. As this plant is almost without thallus the determination is doubtful. It rests between *crustulata* and *subgyratula*. The somewhat gyrose apothecia suggest the latter. If *subgyratula* is synonymous with *limborina*, as is stated by Vainio (Lich. Fenn., iv, 88), the reference of this specimen is more doubtful still as there is no indication of brown coloration in the spores.

L. percontigua Nyl. Kyles of Bute, probably from the mainland (98*). The katabolic product giving the yellowish to red coloration with K seems to be variable in amount as the supplementary red coloration is not always very evident.

L. mersata Stirt. Sciur-na-Gillean, Skye (104*).

L. tenebrans Nyl. W. Lomond Hill (85*), though no mature asci could be found in the apothecia. Sciur-na-Gillean, Skye (104*).

L. sympathetica Tayl. Old wall, Gannochy, near Perth (89*). The rock is not calciferous and the apothecia are darker and more innate than in *Biatora fuscorubens*, in which the species is probably better included as a sandstone form.

L. albocoerulescens (Wulf.) Nyl., Braemar (92*), Kinlochleven (97*) W. W., Kyles of Bute (98* or 100*), Stronsay (111*); var. *flavocoerulescens* (Horn.) Schaer, Kinlochleven (97*) W. W.

L. crustulata (Ach.) Krb., Corriemulzie, Morrone, and Braemar (92*), Ben Lomond (86*), Sligachan, Skye (104*); var. *meiospora* (Nyl.) Oliv., Blackcairn Hill, Newburgh (85*), Oban (98*), Quirang (104). In the variety the thallus is thicker and the apothecia are arranged concentrically. None of the specimens belong to Vainio's *meiosporella* (under which he includes most specimens of *meispora*) as the hymenium is only about 70–80 high, whereas in *L. contigua* v. *meiosporella* it is about 110 μ.

L. cinereoatra Ach. Birnam Hill (88*) *leg.* 1858. This agrees with the description of *f. tumidior* Vain., Lich. Fenn., iv, 175. It shows slight differences from Lamb's description in his Lich. Notes, ii, J. of Bot., 1938. The paraphysial apices are brownish and do not give a "beautiful rose-red" with nitric acid. The acid which I used was not fuming but gave a good coloration with *L. crustulata* and especially with *L. lithophila*. The specimen which Lamb described is probably British, though no definite locality was given for it. Form *subinnata* Vain., Muirhall, Kinnoull Hill (89*).

L. confluens (Web.) Ach. Lochnagar (92*), an almost ecrustaceous form.

L. cinerascens (With.) A. L. Sm. Ben Lomond (86). This has the characteristic look of the plant and also agrees in the intimate structure of the thallus and apothecia except that the medulla shows no definite blue with iodine. After treating with K and washing some slight blue coloration is shown after adding iodine, and this rather suggests that the normal formation of the amyloid substance had been prevented by some external influence.

L. dealbatula Nyl. Bushiel Dean (81*) Hardy. Scrabster (109). Broad spores seem to be the chief character distinguishing this from allied species. The apothecia in these two specimens are neither umbonate nor subgyrose, but the same remark applies to some of the Br. Mus. specimens.

L. auriculata Th. Fr. A number of specimens from various hill districts belonged to this species or its variety *diducens*. The flexuose character of the thalline margin was very variable. A plumbeous form from the summit of Ben Macdhui agreed intimately in the internal structure of the apothecia.

L. Dicksonii Ach. Kinlochleven (97*) W. W.

L. armeniaca (DC.) Fr., Birnam Hill (88), Sciur-na-Gillean, Skye (104*); form *melaleuca* (Somm.) Fr., Birnam Hill (88*). A specimen collected by Wheldon and Wilson from Ben Lawers also belongs to this form.

L. fuscoatra (L.) Ach., Quirang, Skye (104*); form *roridella* Vain., L. Fenn., iv, thalline areolae opaque, pale-greyish or ± brick-coloured, lightly pruinose especially at the margins, apothecia with pruinose disc, Tayport (85*), Balthayock (89*), a form new to Scotland, but previously noted from N. Wales; var. *grisella* (Flk.) Nyl., top of Norman Law (85*), Quirang (104*); var. *Mosigii* (Ach.) Nyl., Birnam Hill (88), Quirang (104); apothecia are somewhat pruinose. Vainio includes most of the specimens given by Nylander as *grisella* under *Mosigii*.

L. fuscocinerea Nyl. Sciur-na-Gillean, Skye (104*). It is probably also present on some scraps of rock collected in 1856 between Spittal of Glenshee (89) and Braemar (92), but is so intimately associated with *Acarospora sinopica*, *Bacidia umbrina*, and Rhizocarpon that it cannot be stated definitely to be present.

L. xanthococca Somm. A plant collected by Hardy at Retreat (81) does not show its spores, and neither Hardy nor Lindsay gave it a name, but its general characters seem to place it here.

L. expansa Nyl. On compact felspar, Pentland Hills (85*).

L. commaculans Nyl. Lochnagar (92) *leg.* Lindsay in 1856. The type specimen came from the summit of Morrone and was not collected till 1868.

L. sylvicola Flot. Bushiel Dean (81) Hardy, comes in the ambit of this species. The thallus and spores are agreeable and the upper portion of the hymenium is often bluish, though not always so.

L. plumbea Garov. A plant from a granitic rock, Garrynahine, Lewis (110), has a leaden-coloured thallus like *L. plumbea*, which has not been recorded from the British Isles. The outer areolae are sometimes stated to have a radiate arrangement, but the Garrynahine specimen is incomplete and does not show the marginal portions. The apothecia are immature, but they suggest an Aspicilia. Vainio in Lich. Fenn., iv, 190, considers that *L. plumbea* is an Aspicilia.

Pertusaria globulifera Nyl. Woods on the Devon near the Falls (85). This belongs to form *discoidea* Cromb., which has been elevated to specific rank as *P. discoidea* Malme. As the soralia are small it comes under *P. discoidea* f. *minor* Erichs.

P. pertusa f. *polycarpa* (Boist.) = *P. communis* f. *polycarpa* Boist., Penmanshiel (81*) Hardy: f. *rupestris* DC., = *P. rupestris* (DC.) Schaer., Penmanshiel (81*) Hardy; var. *leiotera* (Nyl.) Zahl., = *P. leioterella* Erichs., Cockburnspath and near Dunglass (81*) Murray Lindsay, 1856. Arniston Woods, near Edinburgh (83*).

P. concreta Nyl. W. Lomond Hill (85*). Hill behind Oban (98*). Quirang, Skye (104*), but young and coloration with K not decidedly red, merely reddish brown, probably because the katabolic product has not been developed in sufficient quantity.

P. coccodes (Ach.) Nyl. Inverarity (90*). Detected in some material sent by Miss U. Duncan. It belonged to the form *bacillosa* Nyl.

P. inquinata f. *nolens* (Nyl.) Boist. Another specimen of this was collected in 1856 by Lindsay on the roadside between Uig and Quirang (104).

P. Wulfenii DC., Withernsea (61*) collector unknown, woods on the Devon near the Falls (85*); form *carnea* Fr., Ben Lawers (88*). Var. *glabrescens* Nyl., woods on the Devon near the Falls (85*), Killarney Castle (I. 2*) Carroll. Both these specimens may go under *P. constricta*, one of Erichsen's segregates which differs mainly from *P. Wulfenii* in the disc of the apothecium remaining punctiform and its margin not or little swollen. Var. *rugosa* (Ach.) Nyl. Ben Lawers (88*).

P. dealbescens Erichs. A specimen from a weathered basaltic boulder, W. Lomond Hill (85*), is probably to be placed here, also one from the Cairnwell (89*) *leg.* E. C. W.

P. amarescens Nyl. Glenshee (89*) D. A. J.

P. leioplaca (Ach.) Schaer., Birnam (88), Ben Nevis (97); form *juglandis* Hepp, – *P. leucostoma* (Bernh.) Mass., Glen Lyon (88*) *leg.* U. D., Balthayock (89*) with a fungus parasitic on it.

Acarospora scyphulifera Wain. Stronsay (111*). New to Scotland.

A. sinopica Krb. Between Spittal of Glenshee and Braemar (89 or 92), has been recorded for both these vice-counties previously.

Biatorella privigna (Ach.) A. L. Sm. On calciferous rock, Ayton (62), Mudd, 1855, labelled *Endocarpon smaragdulum* v. *privigna*. A Biatorella with minute apothecia having a colourless hypothecium is sparingly present and is probably *privigna*. The main portion, however, belongs to a verrucarioid lichen with green algae and paraplectenchymatous cells (see *Thelidium acrotellum*).

Ramalina calicaris (L.) Fr. Dryburgh (81*) D. A. J.

R. farinacea (L.) Ach. Trislaig (97*) W. W., Iona (103*) L. B. T., Golspie (107*) E. C. W.

R. fraxinea (L.) Ach., Altinarloch (109*) E. C. W.; var. *calicariformis* Nyl., Wick (109*) E. C. W.

R. pollinaria Ach. Near Wick (109*) E. C. W.

R. subfarinacea Nyl. Iona (103*) L. B. T., Stoer (108*) E. C. W.

R. curnowii Cromb., near Montrose (90*) *leg.* Boswell, herb. Oxford.

R. scopulorum form *tuberculosa* Oliv. Orkney (111*). The plant, *leg.* H. H. Johnson and labelled *R. polymorpha*, belongs to the above. The bodies considered as soredia are spermogoniferous tubercles.

Lecania erysibe (Ach.) Mudd. A plant collected by W. Johnson in 1879 from Weardale (66*) was overrun with Gloeocapsa and this was probably the reason why it was left unnamed.

L. syringea (Ach.) Th. Fr. Near Aberfeldy (88*) Hugh Macmillan.

Thalloidima cumulatum (Somm.) Hellb. Gunnerton Crags (67*) W. Johnson.

T. squalescens (Nyl.) Th. Fr. as subgenus, = *Bilimbia sabuletorum* v. *simplicior* A. L. Sm., p.p. Sciur-na- Gillean, Skye (104*).

T. tabacinum (Ram.) Krb. Ben Lomond (86*), 1855. New to British Isles. Thallus dark-brown, sometimes with a reddish tint, with lobes mostly thick and swollen, often ± globular and sometimes with a circular folding; apothecia dark, appressed, plane, marginate or not; paraphyses ± discrete, clavate at darkened tips which are brownish or bluish and become violet-blue with K; spores, colourless, 1-septate, about 16 × 3 μ.

Biatorina globulosa (Flk.) Krb. On twigs, Stornoway (110*). Another plant collected on moss and soil between Sligachan and Portree, Skye (104*), agrees well with *B. globulosa* as regards internal characters, and it may be considered as a muscicolous form. Its thalline granules have some yellowish coloration with K, but the epithecium is too dark and the hypothecium too brownish for *B. Griffithii.*

B. Griffithii (Sm.) Mass. Near Tynehead, Edinburgh (83*).

B. erysiboides (Nyl.) Th. Fr. Blaeberry Hill (89*).

B. cyrtella (Ach.) Th. Fr. On twigs, Stornoway (110*).

B. atropurpurea (Schl.) Ach. Kinlochleven (97*) W. W.

B. lenticularis (Ach.) Krb. Kinnoull Hill (89). The dark apothecia and the apices of the paraphyses less globose than usual suggest *B. obturbans*, but the thallus is not so rough, does not give the slightest yellow coloration with K, the apothecia are rather too subinnate and the spores are less than 11 μ long.

B. contristans (Nyl.) A. L. Sm. Summit of Ben Macdhui (92* and 94*), with thallus little evident, *Anthelia Juratzkanum* almost covering the soil except where apothecia occur. Sciur-na-Gillean, Skye (104*), with thallus paler than usual.

B. synothea (Ach.) Krb. Glen Doll (90*) U. D.

Catillaria premnea (Fr.) Krb. Bald Crag, Moffat (72*) Sadler, 1858.

C. chalybeia (Borr.) Mass. Fort William (97*) W. W.

Microphiale diluta (Pers.) Zahl. Raasay (104*) U. D.

Icmadophila ericetorum (L.) Zahl. Troligill (108*) E. C. W.

Toninia carbonacea Anzi. Clapham (64*) Carrington.

T. aromatica (Sm.) Mass. Elie (85*). Montrose (90*) U. D.

Bilimbia sabuletorum (Flk.) Arn. Summit of Macdhui (92* and 94*). For v. *simplicior* see *Thalloidima squalescens.*

B. lignaria (Ach.) Mass. On moors, Twice-brewed-ale, Northumberland, probably in v.c. 68*, *leg.* Sadler. L. Coruisk, Skye (104*).

B. Naegelii (Hepp) Anzi. On twigs, Stornoway (110*).

B. melaena (Nyl.) Arn. Glen Nevis (97*) W. W.

B. leucoblephara (Nyl.) Arn. On boulder, Kinnoull Hill (89*).

Internally the specimen agrees well with my Achill specimen except that the spores are larger though well within the limits given for the species. The absence or faintness of coloration with K can be ignored as Larbalestier's specimens show none and my Achill specimen is also negative. The apothecia show very slight (or no) indications of whiteness around, but this is probably owing to the paucity of the thallus, as in some thin parts of authenticated specimens the whiteness is absent or little evident.

Bacidia luteola (Schrad.) Mudd. Ingleborough (64*) in herb. Oxford. On old elms, Inverary Woods (98).

B. effusa (Sm.) Arn. On alder, Retreat (81*) Hardy. Rostellan (I. 5*) Carroll.

B. umbrina (Ach.) B. & R. Gannochy (89). Near Sligachan (104*).

B. pulvinata (Tayl.) Mudd. Glen Nevis (97*) W. W.

Lecanactis abietina (Ach.) Krb. Horsley Hope (66) Thornhill and W. Rob. This is labelled *Pyrenula leucocephala* and is mainly the spermogonial condition of *L. abietina*. One or two apothecia are present and probably a note on the paper to which the specimen is attached refers to these apothecia. This note reads: "*Lecidea albocoerulescens* to which, according to Mr. Borrer, *L. pruinata* of Dickie is closely allied or perhaps not distinct from it." *L. albocoerulescens* Ach. has a different use to-day, and Dickie's *L. pruinata* is given by Hooker as a synonym of *Biatorella pruinosa.*

Xanthoria parietina (L.) Th. Fr., Lochmaben (72*) Richardson in herb. Oxford; var. *ectanea* (Ach.) Oliv., Scrabster (109*).

Placodium lobulatum (Flk.) Flag. Trislaig (97*) W. W.

P. erythrocarpum (Pers.) Anzi. Dulaw Burn (81*) Hardy.

Callopisma citrinum v. *flavocitrinum* (Nyl.). Portree (104*).

C. cerinum (Ehrh.) DN. Colvend (73*) Richardson in herb. Oxford.

C. pyraceum (Ach.) Arn. L. Fad (100*).

C. caesiorufum (Ach.) Wats. Trislaig (97*) W. W.

C. rupestre (Scop.) Wats. Assynt (108*) H. H. K.

C. ferrugineum v. *festivum* (Ach.) Mudd. Glen Nevis (97*) W. W.

Candelariella vitellina Müll. Golspie (107*) E. C. W.

Physcia stellaris f. *granulata* B. de Lesd. L. Freuchie (88*).

P. hispida v. *tenella* f. *ascendens* Fr. Trislaig (97*) W. W.

P. aipolia (Ach.) Nyl. Colvend (73*) Richardson in herb. Oxford.

P. subdetersa Nyl. Auldbar (90*) U. D.

P. elaeina (Borr.) Leight. Beld Craig (72*) Sadler, 1858.

Rinodina demissa (Krb.) Arn. Trislaig (97*), near Fort William. W. W. Portree (104*).

R. atrocinerea (Dicks.) Krb. Trislaig (97*) W. W.

Buellia spuria (Schaer.) Krb. Morrone (92*).

B. discolor (Hepp) Krb. Balthayock Wood, near Perth (89*). This is near to *B. interpolata* (Stirt.) A. L. Sm., which is perhaps not distinct. Leighton gives a colour reaction with C, but his statements in regard to this reaction are not always accurate. The specimen has a negative or faint reaction to C.

B. myriocarpa f. *stigmatea* Krb. Kyles of Bute (98*), possibly 100*.

B. disciformis (Fr.) Mudd. Colvend (73*) Richardson in herb. Oxford.

B. aethalea (Ach.) Th. Fr. Amulree (88*). Morrone (92*). L. Fad, Bute (100*).

B. verruculosa (Borr.) Mudd. W. Lomond Hill and Norman Law (85*). Loch Fad (100*).

B. excelsa (Leight.) A. L. Sm. Craig Rossie (88*).

B. badioatra was incorrectly shortened to "*B. badia*" in my Lich. Notes in these Transactions for 1939. Lamb, in Lich. Notes, J. of Bot., 1940, considers that the var. *atrobadia* to which my note referred should be placed under *Rhizocarpon polycarpum* (Hepp) Th. Fr.

B. alpicola (Wahl.) Kremp. Lochnagar (92*). Summit of Cairngorm (96*). Lamb, in the Lich. Notes previously referred to, suggests that the Ben Nevis specimen referred to in my Lich. Notes in these Transactions for 1939 as differing from *B. alpicola* in some details, should be placed under *Rhizocarpon crystalligenum* Lynge. He also uses the combination *R. oreites* (Wain.) Zahl. for our common form of *B. alpicola*.

B. conferroides Kremp. Amulree (88*). This is not our usual British plant to which Lamb has given the new specific name of *atlanticum*, but belongs to *Rhizocarpon polycarpum* (Hepp) Th. Fr. The use of two generic names for this and some other preceding and following species seems to require some explanation. The use of Buellia and Rhizocarpon varies according to the basis of classification adopted. In the Monographs of A. L. Smith Buellia has the spores 1-septate, whilst in Rhizocarpon they are more than 1-septate and usually muriform. Some authors attach more importance to the structure of the paraphyses, using Rhizocarpon when they are conglutinate and Buellia when they are not. In this they ± follow Th. Fries, though he cites the halonate character of the spore as the distinguishing feature. This is so variable a character that some later authors have largely used the paraphysial distinction as the main character distinguishing the two genera.

B. colludens (Nyl.) Arn., – *Rhizocarpon Hochstetteri* (Krb.) Vain. Summit of Cairngorm (92* and 94*). Between Sligachan and Portree, also Quirang, Skye (104*).

Rhizocarpon alboatrum (Hoff.) Th. Fr. From v.c. 73*, *leg.* Richardson in herb. Oxford. Var. *epipolium* (Ach.) A. L. Sm. Stronsay (111*); form *ambiguum* (Ach.) A. L. Sm., Canty Bay, near North Berwick (82*) Hardy, Elie (85*). Var. *venustum* (Krb.) A. L. Sm. Clapham (64*) Carrington. This is our common British form in which the thallus is negative to K.

R. petraeum f. *impressulum* (Leight.) A. L. Sm., Gannochy (89*); var. *excentricum* (Ach.) A. L. Sm., Hill of Findhaven (90*), Stronsay (111*).

R. distinctum Th. Fr. On greywacke, Bushiel Dean (81*) Hardy, 1856. Between Spittal of Glenshee and Braemar (89* or 92).

R. plicatile (Leight.) A. L. Sm. Blackcairn Hill, Newburgh (85*). Thallus definitely coloured with K or C; with the former there is a distinct yellow which may afterwards become a dirty red, with the latter it becomes yellowish. The thallus is, however, not quite typical.

R. rubescens Th. Fr., a depauperate state from Corriemulzie (92*). Both this name and *R. plicatile* are sometimes justifiably considered as synonyms of *R. coniopsoideum* Hepp. The differences between the lichens represented by the three names are rather inconstant and variable.

R. Oederi (Web.) Krb. Kinlochleven (97*) W. W.

R. obscuratum (Ach.) Mass., top of Norman Law (85*), L. Fad, Bute (100*); var. *roridulum* (Th. Fr.) Elenk. Sciur-na-Gillean, Skye (104*).

R. postumum (Nyl.) Th. Fr. On compact felspar, Pentland Hills (83*), spores about $20 \times 10\ \mu$, with few loculi and indistinct epispore. The spores are slightly larger than given for *R. postumum* and the dark hypothallus is fairly well evident. The hymenial reaction to iodine is blue, but asci and contents are coloured yellowish-brown; this agrees fairly well with the statement in Th. Fr., Lich. Scand., 634, "iodo coerulescit, ascis vinose rubentibus, sporis fulvescentibus." Corriemulzie (92*). Oban (98*).

R. confervoides DC. Pentland Hills (83). L. Fad, Bute (100*). Quirang and Uig, Skye (104*). The specific epithet *confervoides* is not recognised by most continental lichenologists. Theodore Fries considered that De Candolle's *confervoides* was a mixture of several species besides a Rhizocarpon. This might well be the case if the specimen came from a flint pebble-bed, as the epithet "*confervoides*" might apply to several other plants from this habitat. Commonly the epithet "*confervoides*" is suitable for the two plants for which it is used in A. L. Sm. Mon., one being the Rhizocarpon and the other a Buellia. According to the frequency given by the continental botanists *R. grande* should correspond to our *R. confervoides*, but the majority of British plants which I have examined have paraphyses which lack the purplish colour attributed to *R. grande* and rather conform to *R. reductum*, though this is not the case with this lot of specimens which may be placed under the following four species. *R. grande* (Flk.) Arn. W. Lomond Hill (85). Ben Nevis (97). Quirang and between Sligachan and Portree (104). Stromness and Kirkwall (111). *R. reductum* Th. Fr. Craigie Hill (88). On examining one apothecium the specimen was referred to this, but on examining a second apothecium *R. grande* seemed preferable. Forteviot (88). Between Spittal of Glenshee (89) and Braemar (92). *R. intersitum* Arn. Amulree (88). Thallus brownish or yellowish-brown, cracked-areolate, with faint or no reaction with reagents. Apothecia dark, small, appearing innate or subinnate, with flat disc and entire margin; epithecium dark brown, K-; hymenium about 100 μ, with iodine blue, then sordid with ascus wall red; paraphyses conglutinate; hypothecium dark, K–, with hyphae $\pm$ erect above but soon becoming irregular; spores 8, colourless, halonate and 3-septate at first, then becoming darker and with many muriform divisions, finally dark brown and up to 34×15 μ. *R. transiens* Eitner. Kinnoull Hill (89). In the first apothecium examined the spores were small, colourless, and few-celled, but other characters were not agreeable for any of the small-spored species. The second apothecium examined showed some indications of dark septa in the somewhat larger spores. The third and largest apothecium examined showed halonate spores which were mostly colourless, but some darker especially at the septa, mostly small but some larger and up to 30 μ long and with many loculi. The margin of the apothecium is persistent as in *R. transiens*, but spores are not usually pointed, may have more numerous cells and the asci are sometimes relatively broader. The thallus consists of small yellowish-brown (ochre when moistened) granules scattered on a dark hypothallus. If not merely regarded under the broader name "*confervoides*" its characters exclude it from all the other allied species except *transiens*.

Gyrophora cylindrica v. *denudata* T. & B., Cairnwell (89*) E. C. W.; near Sligachan (104*) U. D.; v. *fimbriata* Ach., Slochd Mor (94*) E. C. W., near Sligachan (104*) U. D.

G. probiscidea form *exasperata* (Gunn.) Cromb., Glen Clova (90*) U. D.; form *deplicans* (Th. Fr.), Cairnwell (89*) E. C. W.; form *fimbriata* Mudd, Slochd Mor (94*) E. C. W.

G. torrefracta (Light.) Cromb. Some specimens labelled *G. erosa* were sent for examination and found to belong here. Whernside (64) T. Hebden. Garrynahine (110). Near Stromness (111*). Muchish Mountain (I. 35) Dickie.

Diploschistes scruposus v. *bryophilus* (Ehrh.) Muell. Balmuto (85*) herb. Greville.

D. gypsaceus (L.) Zahl. St Cyrus (91*) U. D.

Phlyctis argena (Ach.) Krb. A specimen collected by Richardson from v.c. 73* is in herb. Oxford.

Cladonia rangiferina (L.) Web. Ben Avon (94*) E. C. W. The specimen of var. *lappacea* from Cleveland (62) is, as suggested on the label, what has been called *C. alpestris* f. *pumila*. It is, however, better to place it under *C. impexa* as a form.

C. mitis Sands. Ventnor (10*) *leg.* 1840 as *C. rangiferina*. Drumossie (96*) E. C. W. Lamb, in Lich. Notes, ii, J. of Bot., 1938, gives some reasons for calling this *C. subsylvatica* Stirt.

C. impexa Harm. Orkney (111*) H. H. Johnston, 1933.

C. alpestris (L.) Rabh. The specimen so labelled from Orkney is a mixture of *sylvatica*, *impexa*, *uncialis*, and *furcata*, but no *alpestris* is present.

C. uncialis f. *adunca* Ach., Lochinver (108*) E. C. W.; f. *obtusata* Ach., Goatfell, Arran (100*) *leg.* Graham.

C. tenuis Harm. Trislaig, near Fort William (97) W. W., is worth recording though it is not a new v.c. record. It had previously been recorded by Crombie in British Lichens as *C. sylvatica* f. *tenuis* from Glen Nevis.

C. foliacea (Huds.) Willd. Orkney (111*) Johnston.

C. gracilis (L.) Willd., Inchnadamph (108*) E. C. W.; f. *subulata* Hag., Caenlochan (90*) E. C. W., Braeriach (92*) McIntyre, 1822, Raasay (104*) U. D.; f. *aspera* (Flk.) Cromb., Cairnwell (92*) E. C. W.; v. *elongata* (Jacq.) Wain., Cairnwell (89*) E. C. W.

C. lepidota f. *hypophylla* (Nyl.) Cromb. = *C. degenerans* f. *hypophylla* Nyl., Glen Clova (90*) U. D.

C. pyxidata (L.) Hoff., Troligill (108*) E. C. W.; var. *chlorophaea* Flk., Hareshaw (77*), with f. *staphylea*, R. Burn, Torbreck (104*) E. C. W.; f. *mesotheka* Wallr., det. Sandstede, Ben Nevis (97*) E. C. W.

C. pityrea (Flk.) Fr. Rae Hills (72*) McIntyre, with f. *gracilior* Harm.

C. fimbriata (L.) Fr., Newarthill (77*) R. Burn, with forms *prolifera* Retz. and *denticulata* Flk.; v. *subulata* (L.) Wain., Fort William (97*) W. W.; v. *nemoxyna* Coem., Raasay (104*) U. D.

C. ochrochlora Flk. Ethie Wood (90*) U. D., with f. *ceratodes* Flk.

C. verticillata f. *phyllophora* Flk. Ben Lawers (88*) U. D.

C. cervicornis f. *stipata* Nyl. Ardgour (97*) and Clachtoll (108*) E. C. W.

C. subcervicornis Wain. Inchnadamph (108*) E. C. W.

C. cornuta (L.) Fr. Tealing (90*) U. D.

C. crispata v. *infundibulifera* (Schaer.) Wain. Braeriach (92*) McIntyre.

C. Delessertii (Nyl.) Wain. Aonach Beag (97*) E. C. W., det. Sandstede. *C. trachyna* v. *subfurcata* Nyl. in A. L. Sm. Mon. (1918), p. 437, is synonymous.

C. furcata (Huds.) Schrad., near Doon as v. *recurva* in herb. Greville (84), Troligill (108*) E. C. W., Orkney (111*) *leg.* H. H. Johnston; v. *pinnata* (Flk.) Wain., Orkney (111*); v. *scabriuscula* (Del.) Coem., Pentland Hills (83*) McIntyre, 1821 (is f. *aspersa* Flk.), Balerno (83*) McAndrew, 1912, as v. *recurva*, under which A. L. Smith in Mon. places *scabriuscula*, Glen Doll (90*) U. D.

C. rangiformis Hoff. New Galloway (73) McAndrew, labelled *C. furcata* v. *syricae*. Hallaig, Raasay (104*) U. D. Troligill (108*) E. C. W. A plant from Cairnwell (92) E. C. W. had the apices somewhat curved mimicking *C. sylvatica*.

C. squamosa (Hoff.) Scop. Fifeshire (85*) McIntyre, 1822.

C. coccifera (L.) Willd., and v. *pleurota* (Flk.) Schaer. Troligill (108*) E. C. W.

C. bacillaris Nyl., and *C. Floerkeana* Fr. Holytown (77*) R. Burn.

C. macilenta Hoff. Raasay (104*) U. D.

Stereocaulon coralloides Fr. On stones, Dysart (85*) *leg.* W. W. Evans, 1845, and labelled *S. paschale*.

S. subcoralloides Nyl. Glen Fiaogh (90*) U. D.

S. paschale (L.) Fr. Ben Avon (94*) E. C. W.

S. denudatum Flk. Troligill (108*) E. C. W.

S. glareosum (Sav.) Magn. Sandy bank of Linn Water, Derry Lodge (92*) E. C. W. For its first British locality, Culbin Sands (95*), see Lamb, Lich. Notes, iii, J. of Bot., 1939.

S. evolutoides (Magn.) Frey. Slochd Mor (94*) E. C. W. It has been recorded from 92* and 96* by Lamb, *ibid.* He also named one of Wallace's plants from Caenlochan (90*) as this.

S. condensatum Hoff. Near Aviemore (96*) *leg.* D. A. J. Var. *condyloideum* Nyl. High situations in the north-west of Durham (66) *leg.* 1815 and, according to the label, *S. condyloideum* Ach. b. *suboccultatum* on the authority of Acharius.

Baeomyces rufus v. *subsquamulosus* Nyl. Blaeberry Hill (89*).

B. roseus Pers. Hills east of Sligachan, Skye (104*).

B. placophyllus Ach. Blaeberry Hill (89). Glen Spean (97) W. W.

Pilophorus cereolus (Ach.) Th. Fr. Glen Nevis (97) W. W. Sligachan (104).

Gyalecta cupularis Schaer. Over moss, Dulaw Dean (81) Hardy. The peculiar habitat accounted for its unnamed condition.

Crocynia lanuginosa v. *albescens* B. de Lesd. Campsie (86*) as *Bombyliospora incana.* Gannochy, near Perth (89*).

Stictina fuliginosa (Dicks.) Nyl. Assynt (108*) H. H. K.

S. limbata (Sm.) Nyl. I. of Barra (110*) det. I. M. L.

S. Dufourii (Del.) Nyl. Slemish Mountain (I. 39*) Moore.

S. intricata v. *Thouarsii* (Del.) Nyl. Hallaig, I. of Raasay (104*) U. D.

Lobaria pulmonaria (L.) Hoff. Kyleakin, Skye (104*) Boswell in herb. Oxford.

L. laetevirens (Light.) Zahl. I. of Barra (110*) det. I. M. L.

Peltigera spuria DC. Strathmartine (90*) herb. Oxford.

P. polydactyla v. *hymenina* (Ach.) Nyl. From 73* in herb. Oxford *leg.* Richardson.

P. rufescens v. *lepidophora* (Nyl.) Wain. Ardgour (97*) E. C. W.

Peltidea venosa (L.) Ach. Specimen from 73* in herb. Oxford *leg.* Richardson.

Pannaria Hookeri (Borr.) Nyl. Quirang, Skye (104*). The apothecia are browner or redder than in the Ben Lawers specimen, but it is certainly the same species.

P. pezizoides (Web.) Leight. Hallaig, Raasay (104*) U. D.

P. rubiginosa (Thunb.) Del. Kyleakin, Skye (104*) U. D.

Nephromium lusitanicum v. *hibernicum* Nyl. Mollins Burn (73*) Richardson in herb. Oxford.

N. laevigatum v. *parile* (Ach.) Nyl. Noranside, Fern (90*) U. D.

Solorina saccata (L.) Ach. A specimen from 73* *leg.* Richardson in herb. Oxford.

Parmeliella plumbea (Light.) Wain. Hallaig, Raasay (104*) U. D.

P. atlantica Degel. Glen Nevis (97*) W. W. Hallaig (104*). As usual associated with *P. plumbea* and so intergrading with it that the plant should be considered as an isidioid form. Apothecia are occasionally found in this form, whilst the type and the form occur on the same tree.

Placynthium nigrum (Huds.) Gray. Kinnoull Hill (89*).

Leptogium sinuatum (Huds.) Mass. Hallaig, Raasay (104*) U. D.

L. lacerum (Lil.) Gray. Inverarity, Raasay (104*) U. D.

L. palmatum (Huds.) Mont. herb. Menzies without locality.

L. Schraderi (Bernh.) Nyl. From 73* *leg.* Richardson in herb. Oxford.

L. plicatile (Ach.) Th. Fr. Inverlochan (97*) W. W.

Collema pulposum (Bernh.) Ach. From 73* *leg.* Richardson in herb. Oxford.

C. cheileum Ach. Ben Lomond (86*). Montrose (90*) U. D. is form *graniforme* Harm.

Synechoblastus polycarpus (Sch.) D. T. & S. Assynt (108*) H. H. K.

S. rupestris (Sw.) A. L. Sm. Glen Falloch (87*) Richardson in herb. Oxford.

Ephebe lanata (L.) Wain. Between Sligachan and Portree (104*).

Spilonema paradoxum Born. L. Coruisk, Skye (104*) *leg.* 1856. The specimen consists chiefly of Stigonema, but some portions have fungal hyphae around and penetrating though no apothecia were found.

Thermutis compacta (Kutz.) A. L. Sm. L. Coruisk, Skye (104*) U. D.

Euopsis pulvinata (Schaer.) Wain. Summit of Ben Lawers (88), 1851. Stirton there collected the first recorded Scottish material twenty years later.

Arthonia lurida v. *spadicea* (Leight.) Nyl. Berwickshire (81*) Hardy. As in many other specimens of *lurida* some protococcoid algal cells are present. The hymenial coloration with iodine is given in A. L. Sm. Monog. as dirty red, but some blue coloration is given in this specimen and, after treating with K and washing, a good blue is obtained with iodine. The specimen does not agree with *spadicea* as described by Lindau and Migula.

A. gregaria (Weig.) Krb. From 73* in herb. Oxford *leg.* Richardson.

A. punctiformis Ach., Lasswade (83*) herb. Greville; v. *melantera* (Ach.) Leight., Lasswade (83*) herb. Greville.

Allarthonia patellulata (Tayl.) Zahl. On alder, Retreat (81*) Hardy.

Melaspilea lentiginosa (Lyell) Zahl. New Forest (11) C. Lyell, a type or co-type specimen.

Opegrapha atra Pers., Oxford (23) Baxter as *O. hapalea*, but not the plant of Acharius; Fort William (97*) W. W.; v. *denigrata* (Ach.) Schaer., in herb. Oxford, collected by Richardson from v.c. 73*.

O. confluens Stiz. Stronsay (111*).

O. saxicola v. *Persoonii* (Ach.) Stiz. Clapham (64*), 1859, associated with a fungus having brown simple spores, 5 or more in ascus, about $16 \times 8\ \mu$. The same fungus, apparently on the thallus of *Rhizocarpon alboatrum* v. *epipolium* was collected in the same locality by Carrington in 1857.

O. calcarea Turn. Canty Bay (82) Hardy, Stronsay (111*).

Graphis elegans (Borr.) Ach., and f. *parallela* Leight. Fort William (97*) W. W.

G. scripta (L.) Ach. Raehills (72) Richardson, 1824, in herb. Greville. Fort William (97*) W. W.

Phaeographis inusta (Ach.) Muell. From v.c. 73* *leg.* Richardson in herb. Oxford.

Chaenotheca trabinella (Ach.) A. L. Sm. Parkhill, near Arbroath (90*) U. D. New to Scotland.

Calicium quercinum v. *lenticulare* (Ach.) Nyl. Killin (88*) U. D.

Stenocybe byssacea (Fr.) Nyl. On alders, Trislaig, near Fort William (97*) W. W.

Coniocybe furfuracea (L.) Ach. Kinlochleven (97*) W. W.

Sphaerophorus globosus f. *congestus* Lamy. Glen Troligill (108*) E. C. W.

Dermatocarpum aquaticum (Weiss) Wain. On stones submerged in a rivulet, near Aberdeen (92*) Dickie, 1849. A small form with apothecia.

D. hepaticum (Ach.) Th. Fr. Kinnoull Hill (89*). Arbroath (90*) U. D. Kyles of Bute (100*).

Verrucaria maura Wahl. L. Coruisk, Skye (104*).

V. scotina Wedd. Scrabster (109*).

V. papillosa Ach. Great Chester (68*) Sadler. Callander (87*).

V. aethiobola Wahl. Bracklinn Bridge (87*).

V. aquatilis Mudd. Glen Nevis (97*) W. W.

V. prominula v. *minor* A. L. Sm. Weardale (66*) W. Johnson, 1879. Balthayock (89*). Lerwick (112*).

V. aquilella Nyl. Butlerstown, near Cork (I. 3*) Carroll.

V. coerulea DC. Glenshee (89*) D. A. J.

V. fusconigrescens Nyl. Clapham (64*), 1859. Similar to *V. mauroides* Schaer., but the thallus is often paler in colour and the lower portion of the perithecium is almost colourless. This species (if it is worthy of such a status) has hitherto not been recorded for the British Isles.

V. cyanea Mass. On calcareous rock, Methven (88*). For recorded British species it agrees best with this. It is too indefinite to place either with *V. amylacea* Kremp. or *V. lilacina* Mass., though it may possibly belong to one or the other, neither of them being recorded as British.

V. rupestris Schrad. Braemar (92*).

Normandina pulchella (Borr.) Cromb. Raasay (104*) U. D.

Thelidium papulare (Fr.) Arn., Bracklinn Bridge (87*), is preferably considered as a form of this with small apothecia rather than *T. cataractarum* as the thallus is too cracked and the spores too large for the latter; f. *arenarium* (Hepp) Zsch., on non-calciferous shale, Birnam Hill (88*). The form chiefly differs from the usual calcicolous plant in having smaller and more superficial perithecia with dark wall thinner below.

T. acrotellum Arn. On calciferous rock, Ayton (62*) Mudd, 1855. A verrucarioid lichen with green algae and paraplectenchyma constitutes the main portion of a specimen labelled *Endocarpon smaragdulum* v. *privigna* (see *Biatorella privigna*). It agrees fairly well with Arnold's description, though the thallus does not now become greenish when moistened and the spores are rather smaller than usually given. The darkish brown, minute (about 0·1 mm.), emergent perithecia are apparently without special involucrellum, the ostiole is minute and the paraphyses soon disappear. Hymenium wine-red with iodine, asci about $60 \times 20\ \mu$, ± spindled at one or both ends; spores colourless, 1-septate, $14–16 \times 6·5–8\ \mu$, often smaller at one end as figured in Migula, Fl. Deutsch. This has not previously been recorded from Britain.

Staurothele rupifraga (Mass.) Arn. L. Coruisk, Skye (104*).

Polyblastia theleodes (Somm.) Th. Fr. Bracklinn Bridge (87*).

Acrocordia biformis (Borr.) Oliv., near Inverarish, Raasay (104*) U. D.; var. *conformis* (Nyl.) A. L. Sm., Lasswade (83*) herb. Greville.

Arthopyrenia cinereopruinosa (Schaer.) Krb. Dumfries (72*) Richardson in herb. Greville.

A. pyrenastrella (Nyl.) Oliv. On old beeches, Castlebernard (I. 3*) Carroll. Near Onich (97*) W. W.

A. analepta (Ach.) Mass. Near Edinburgh (83*) herb. Greville.

A. stigmatella (Sm.) A. L. Sm. In herb. Oxford from v.c. 73*, *leg.* Richardson.

A. microspila Krb. A specimen mimicking in some respects this plant, but it is a fungus. There are no algal cells present with the hyphae and the perithecia are situated on a subiculum of brown, shortly septated fungal filaments. Penmanshiel (81) Hardy.

Leptorhaphis epidermidis (Ach.) Th. Fr. Tarbet (99*).

Melanotheca gelatinosa (Chev.) Nyl. Lasswade (83*), 1825, herb. Greville.

The following fungi parasitic on, or mistaken for, lichens were noted :—

Discothecium gemmiferum (Tayl.) Vouaux. On Pertusaria, W. Lomond Hill (85*).

Karschia lignyota Sacc., as *Arthonia melaspermella* from v.c. 17.

Pharcidia dispersa (Lahm) Wint., = *Epicymatia thallina* (Sacc.) Cooke, as a Verrucaria from Penmanshiel (81) Hardy.

P. epicymatia (Wallr.) Wint., = *E. vulgaris* Fuckel, is not uncommon on the apothecia of Lecanora species.

Ticothecium pygmaeum v. *erraticum* (Mass.) Keissl. On *Buellia alpicola*, summit of Lochnagar (92*). On *Lecidea fuscoatra*, Balthayock (89*).

Tympanis pinastri Tul. Apparently considered as a Biatorella. Kyles of Bute (98). Blaeberry Hill (89) may be the same species. Some other fungi are mentioned in the general text.

The Genus Primula: Section Amethystina. By W. Wright Smith and H. R. Fletcher.

(Read 23rd April 1942.)

This section was proposed by Balfour in his analysis of the "Chinese Species of Primula" at the 1913 Conference (1). He was the first to recognise that the species then known constituted a very distinct section. The diagnoses and earlier comments on *P. Kingii*, *P. Dickieana*, and *P. amethystina* indicated that these species were akin, but gave no evidence as to their relationship with other members of the genus. In 1905 Pax in his Monograph (2) placed these three along with *P. Faberi* and *P. Pantlingii* in his section Callianthae which contained many incongruous species. Balfour (1) dealt only with the Chinese species, and under his tentative definition of the new section he included *P. amethystina*, *P. brevifolia*, *P. Fargesii*, and *P. silaensis*, adding incidentally the Himalayan *P. Kingii*. But he placed *P. Faberi* and *P. argutidens* (compared by Franchet to *P. sapphirina*) within the section Soldanelloideae. It is clear that Balfour regarded the section Amethystina as closely allied to Soldanelloideae, for both have bell-shaped corollas, but beyond referring to the horny leaf-margin in Amethystina he did not formulate the distinctions between them. The proper content of the section was given by Smith and Forrest (3) in an enumeration of the species known up to 1928. They considered the section as somewhat isolated, with possibly a slender link with the Farinosae. Bruun's cytological investigations (4) in 1932 made no mention of Amethystina as material was not available. But in 1935 two species were in cultivation and their examination by Bruun is referred to by Smith (5) (*l.c.*, 165). In Bruun's opinion the karyotype of Amethystina is very like those of Petiolares and of Nivales. However, the observations of Cooper on the development of the young leaves in certain sections of Primula (Smith (5)) have been extended to Amethystina (Smith (6)). In the past it has been assumed that in the bud the leaves are revolute, as in the great majority of the Primulas. This is not the case. The leaves are either involute or take an intermediate position between involute and revolute—a somewhat flattened

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condition without a tendency either way. It is therefore more than likely that the correct position of Amethystina is with the Involutae and in association with the sections Auricula, Cuneifolia, and Parryi. This view is supported by further characters in the leaves and in the capsule. From the three sections mentioned Amethystina diverges to a considerable extent in the form of the corolla and in its seeds.

The sectional characters can be thus summarised. The leaves are more or less involute before unfolding; they are of fleshy or at least firm texture, have usually a horny margin with more or less remote teeth, are without hairs and without farina; they are copiously marked by a glandular foveolation resembling the result of prickings of a needle. The inflorescence is glabrous and efarinose except for a trace of farina in one or two species. The corolla is always bell-shaped with one exception, and is usually exannulate, but a faint annulus is present in *P. amethystina* and its vars., *P. Kingii*, *P. odontica*, and *P. Virginis* in pin-eyed flowers only. The capsule is short and is usually as long as the calyx or slightly longer.

If correctly referred to the Involutae—and its vegetative structure favours that view—the section is the only one in that primary division with a bell-shaped corolla. Its earlier association with Soldanelloideae was no doubt due to similarity in corolla-form. But the campanulate type of corolla occurs in various unrelated sections and is not a fundamental phyletic character. There is a general resemblance between these two sections, but the divergence in foliar structure is very marked. The species allocated to the section are nearly all in conformity with the general description already given. The only notable exception is *P. Dickieana* and its varieties which have a corolla with patent lobes and bear numerous hairs at the throat and within the tube. But in other respects they do not deviate and are certainly members of the section. In them as also in *P. Faberi* there are occasionally traces of farina, but the section as a whole is efarinose.

The distribution is wholly Asiatic and is, moreover, confined to the mountainous regions where the Eastern Himalaya, S.E. Tibet, S.W. China, and extreme Northern Burma are more or less in touch. Into these parts the other sections of the Involutae do not penetrate. In fact all five sections occupy distinct geographical areas (excepting the case of *P. suffrutescens*). The species of the section are obdurate in cultivation. Records show that only *P. Kingii*, *P. amethystina* and its subspecies, and *P. odontica* have flowered in gardens in this country but do not long survive. Seedlings of *P. Dickieana* and *P. Valentiniana* have been raised but got no further.

REFERENCES.

(1) Journ. Roy. Hort. Soc., xxxix, 153 (1913).
(2) Pax in Engl. Pflanzenr. Primul., 114 (1905).
(3) Notes Roy. Bot. Gard. Edin., xvi, 12 (1928).
(4) Cytological Studies in Primula in Symbol. Bot. Upsal., i (1932).
(5) Proceed. Linn. Soc., 164 (1932–33).
(6) Bot. Mag., 9410 (1935).

The species contained in this section are as follows:—

- P. amethystina *Franch.*
  - Subspecies—
    - P. argutidens *Franch.*
      - *P. Riae* Pax.
    - P. brevifolia *Forrest.*
- P. Dickieana *Watt.*
  - *P. Pantlingii* King.
    - var. aureostellata (*Balf. f. et Cooper*).
    - var. chlorops *W. W. Sm.*
    - var. Gouldii *Fletcher.*
- P. Faberi *Oliv.*
  - *P. cylindriflora* Hand.-Mzt.
  - *P. Lecomtei* Petitm.
- P. Kingii *Watt.*
  - *P. Gageana* Balf. f. et W. W. Sm.
- P. odontica *W. W. Sm.*
- P. silaensis *Petitm.*
- P. Valentiniana *Hand.-Mzt.*
- P. Virginis *Lévl.*
  - *P. leimonophila* Balf. f.
  - *P. petrophyes* Balf. f.

KEY TO THE SPECIES.

A. Corolla campanulate, lobes in line with the tube, inside of tube and throat glabrous or obscurely hairy:
  B. Bracts small, not concealing the calyx. Corolla never yellow:
    C. Leaf-margin denticulate or almost entire:
      D. Leaves usually obovate, oblong or oblanceolate. Corolla-lobes round or elliptic:
        E. Blade of leaf much rounded at apex and often as broad as long. Flowers violet to shades of blue. Seeds vesicular-surfaced:
          F. Slender plant with corolla 8–10 mm. long . *silaensis*
          FF. More robust plant with corolla 1·5 cm. long . *amethystina*

EE. Blade of leaf more or less pointed at apex and generally much longer than broad. Flowers wine-red or crimson. Seeds smooth:
  F. Calyx as broad as long. Base of corolla widely extended. Corolla-tube hairy inside . *Valentiniana*
  FF. Calyx longer than broad. Base of corolla elongate-tubular. Corolla-tube glabrous . . . *Kingii*
DD. Leaves lanceolate and very acute. Corolla-lobes narrow-oblong . . . . *Virginis*
CC. Leaf-margin very coarsely dentate . . . . *odontica*
BB. Bracts very conspicuous, almost concealing the calyx. Corolla yellow . . . . *Faberi*
AA. Corolla funnel-shaped, lobes patent, inside of tube and throat with long conspicuous hairs . . . . *Dickieana*

P. amethystina Franch. in Bull. Soc. Bot. Fr., xxxii, 268 (1885); Pax in Engl. Bot. Jahrb., x, 213 (1889); Forbes et Hemsl. in Journ. Linn. Soc., xxvi, 36 (1889); Pax in Engl. Pflanzenr. Primulaceae, 118 (1905)—pro parte; Petitm. in Bull. Soc. Sc. Nancy, Sér. 3, viii, 8, c. fig. (1907); Balf. f. in Journ. Roy. Hort. Soc., xxxix, 131, 154 (1913); Forrest, *ibid.*, xli, 203 (1915); Smith et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 13 (1928), and in Journ. Roy. Hort. Soc., liv, 22 (1929); Smith in Bot. Mag., t. 9410 (1935), sub *P. amethystina* Franch., subsp. *brevifolia* (Forrest) Smith et Forrest.

This plant was one of the discoveries of Abbé Delavay when stationed at Tali in 1884. It was growing in moist meadows near the summit of Mt. Tsan-Chan, near Tali, at an elevation of about 4000 m. Delavay's specimens were described in the following year by Franchet and the type is in the Paris Herbarium. Nothing more was heard of the plant after 1887, when Delavay collected further material in the original locality, until Forrest visited the Tali Range in 1906 and subsequent years and secured it in good flower and in ripe fruit. Meanwhile in other parts of Yunnan and also in Szechwan other plants were obtained showing a marked resemblance to *P. amethystina* without being identical. These are discussed later as representing two subspecies. The typical plant appears to be confined to the Tali Range and is distinguished by the large broadly bell-shaped corolla and with a greater regularity of outline in the lobes. Franchet assigned his species aptly to kinship with *P. Kingii* and compared the leaves to those of *Bellis perennis*. Its nearest ally is *P. silaensis*. It flowered at Edinburgh in 1916, but is no longer in cultivation. It did not set seed, and there is great difficulty in prolonging the life of the individual plant beyond two or three years.

P. amethystina has a small rootstock girt with a few scales. Leaves in a compact rosette, including the short winged petiole 2–5 cm. long, 1–2 cm. broad, obovate-oblong or ovate-oblong, usually rounded and only occasionally pointed at the apex, cuneate below, finely denticulate at the margin and there somewhat horny, firmly chartaceous to cartilaginous, foveolate-punctate, efarinose. Scape slender, 5–15 cm. high, carrying a more or less unilateral umbel of 2–6 nodding fragrant flowers; bracts 2–5 mm. long, ovate-lanceolate to linear-lanceolate; pedicels 5–15 mm. long, erect in fruit but scarcely lengthening. Calyx cupular or open-campanulate, 4–6 mm. long, nearly as broad, cut to the middle into ovate lobes, obtuse or acute. Corolla bell-shaped, described as violet, amethyst or deep purplish-blue, about 1·5 cm. long; cylindrical base as long as calyx, abruptly expanded upwards; bell 12–15 mm. wide at apex, divided into short subquadrate lobes, broader than long, entire or with a small mucronate tip or again slightly emarginate with a mucro in the notch. In pin-eyed flowers style exceeding calyx by about 1 mm., projecting beyond the slight annulus; stamens set about the middle of the basal cylinder. In thrum-eyed flowers stamens inserted at apex of cylinder, reaching level of calyx; style 1 mm. long; no annulus. Capsule equals calyx. Seeds less than 1 mm. in diameter, quadrate-angled, vesicular-surfaced.

The species is thus represented in Edinburgh:

W. Yunnan: Tali Range (*Delavay*, 108—*cotype*; *Delavay*, anno 1887); (*Forrest*, 1806, 11581, 13533, 30186); (*Native Collector*, 94).

P. amethystina Franch. subsp. **argutidens** (Franch.) W. W. Sm. et Fletcher. *P. argutidens* Franch. in Journ. de Bot., ix, 451 (1895); Petitmengin in Bull. Soc. Sc. Nancy, Sér. 3, viii, 8, c. fig. (1907); Balf. f. in Journ. Roy. Hort. Soc., xxxix, 131, 153 (1913); Smith et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 13 (1928), and in Journ. Roy. Hort. Soc., liv, 22 (1929); Smith in Bot. Mag., t. 9410 (1935), sub *P. amethystina* Franch. subsp. *brevifolia* (Forrest) Smith et Forrest—in nota. *P. amethystina* Franch. Pax in Engl. Pflanzenr. Primulaceae, 118, fig. 33c (1905)—pro parte. *P. Riae* Pax et K. Hoffm. in Fedde Rep. Nov. Sp., xvii, 95 (1921).

This plant is found farther north than the type and the other subspecies, at elevations of 3500–5000 m. in the neighbourhood of Tatsienlu in Szechwan. Franchet's diagnosis in 1895 was based on the collections of Soulié and of Pratt. That acute botanist did not associate his *P. argutidens* with the Tali plant which he had described nine years before as *P. amethystina*, but suggested kinship with

P. sapphirina. The original specimens certainly do not favour alignment at first sight with *P. amethystina.* Pax (*l.c.*) reduced Franchet's species to *P. amethystina*, but he had no Tali material before him and the figure accompanying his statement and attributed to *P. amethystina* is almost without doubt drawn from Pratt 761 (*P. argutidens*). Pax's opinion is opposed by Petitmengin (*l.c.*) in a lengthy article with illustrations. Further collections from the Tatsienlu area are now available but do not serve to solve the problem completely. Some of these are in agreement with *P. argutidens* as described; others suggest a transition to the widely distributed subspecies *brevifolia*. Plants flowered in Edinburgh from Tatsienlu seed favoured *brevifolia*, and that subspecies may well extend to that district. On the evidence it is necessary to keep *P. argutidens* either as a subspecies or as a species, and the association is certainly with *P. amethystina.* It is smaller in habit, the leaves are more markedly dentate, and the flowers decidedly less in size and with shorter pedicels.

A compact tufted plant with a few basal scales. Leaves 2–4 cm. long, about 1 cm. broad, ovate to ovate-oblong, obtuse to subacute at the apex, cuneate below into the very short winged petiole, remotely dentate at the horny margin from the middle upwards, somewhat cartilaginous, foveolate-punctate, efarinose. Scape 7–10 cm. high with an umbel of 2–4 flowers; bracts equalling the pedicels or a little longer, lanceolate, acute; pedicels 1–3 mm. long. Calyx shortly campanulate, 4 mm. long, cut to nearly the middle into ovate to ovate-lanceolate lobes, obtuse or subacute at the apex. Corolla violet, 1–1·2 cm. long, 1 cm. broad at apex; lower cylindric part just exceeding calyx, gradually extended upwards into a bell with subquadrate lobes, 3 mm. long, 4 mm. broad, emarginate, with an apiculus in the notch, or sometimes irregularly incised. Stamens and styles as in subsp. *brevifolia.* Capsule equals calyx. Seeds less than 1 mm. in diameter, vesicular-surfaced.

The type specimen is in the Paris Herbarium and the plant is thus represented in Edinburgh:

W. SZECHWAN. Near Tatsienlu (*Pratt*, 761—*cotype*); (*Wilson*, 3161); Dongrergo (*Harry Smith*, 3267); Tapaoshan (*H. S.*, 11477); Sikang, between Taining and Taofu (*H. S.*, 12518); Gila Pass (*Limpricht*, 1653—*cotype* of *P. Riae*); Ching-tang (*Yü*, 2420).

P. amethystina Franch. subsp. **brevifolia** (Forrest) Smith et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 13 (1928), and in Journ. Roy. Hort. Soc., liv, 22, fig. 15 (1929); Smith in Bot.

Mag., t. 9410 (1935). *P. brevifolia* Forrest in Notes Roy. Bot. Gard. Edin., iv, 229, fig. xl (1908), and in Journ. Roy. Hort. Soc., xli, 203 (1915); Balf. f. in Journ. Roy. Hort. Soc., xxxix, 131, 154 (1913), and in Gard. Chron., Ser. 3, lvii, 207, fig. 63 (1915); Ward in Journ. Roy. Hort. Soc. xlviii, 205 (1923); Hand.-Mzt. in Symbol. Sin., vii, 737 (1936). ? *P. sikangensis* Chen in Bull. Fan Instit. Biol., ix, 273 (1939).

This subspecies is commoner in Yunnan and in Szechwan and also more widespread than the typical *P. amethystina* of the Tali Range. Forrest found the plant in 1905 at elevations of 4000-5000 m. and had the opportunity of comparing the two before describing *P. brevifolia*. At the time, with limited material, the differences appeared significant, but twenty years later his field observations and very extensive collections caused him to change his opinion and to conclude that *P. brevifolia* should be regarded more properly as a subspecies. It is distinguished by the taller and more delicate habit, the more numerous flowers, and the narrower and more irregularly lobed corolla which varies considerably in amplitude but never attains the rounded shape characteristic of *P. amethystina*. It is almost certain that the recently described *P. sikangensis* (*l.c.*) is equivalent to one of these forms of subsp. *brevifolia*. The diagnosis and a figure kindly communicated by the author favour that view.

The subspecies flowered in culture first in 1915 and occasionally since, but is short-lived.

Leaves in all respects similar to those of *P. amethystina*, only occasionally larger. Scape 10-25 cm. high, with 3-20 flowers. The chief divergence is in the narrowly campanulate corolla; lobes generally more or less cut so as to give the appearance of fringing. A white form was collected by Rock on one occasion. Capsule and seeds as in *P. amethystina*.

YUNNAN. On the Mekong-Salwin divide (*Forrest*, 476—*type*, 14213, 19525, 20409); (*Ward*, 84); N.E. of Yangtze bend (F. 10375); Mekong-Yangtze divide (F. 12952, 25729, 25882); Chienchuan-Mekong divide (F. 12952, 15729, 25882); Chungtien plateau (F. 10618, 10911, 12518, 12625, 12639, 30198); (*Rock*, 24632, 24655, 25254, 25261); Kari Pass (F. 13957); Bei-ma Shan (F. 13967, 16573, 16961, 17176, 17256, 19675); Chiusa Shan (F. 30235); Yingbu Shan (F. 30263); S.W. of Shi-Ku (R. 25087, 25412); Haba Shan, Lichiang (R. 24760, 25290); Hung Po (R. 22906).

SZECHWAN. Mountains around Muli (*Forrest*, 16253, 16328, 20479, 20661, 21352, 22503, 28366); (*Rock*, 16021, 16203, 16349, 16656, 17456, 17896, 18146, 23928, 24085); Kausha Shan (R. 14085); near Yenyüen (*Hand.-Mzt.*, 2637).

S. E. TIBET. On the Salwin–Kiu-Chiang divide (*Forrest*, 14213, 18721, 18868, 19127, 22932); Yundshi, west of Kaakerpo (*Rock*, 23217, 23601).

P. Dickieana Watt in Journ. Linn. Soc., xx, 9, t. 84 (1882); Hook. f. in Fl. Brit. Ind., iii, 491 (1882); Pax in Engl. Bot. Jahrb., x, 213 (1889), and in Engl. Pflanzenr. Primulaceae, 115 (1905); Watt in Journ. Roy. Hort. Soc., xxix, 300, 314 (1904); Craib, *ibid.*, xxxix, 188, 189 (1913); Ward, *ibid.*, xlix, 155 (1924), and *ibid.*, lii, 232 (1927), and *ibid.*, lviii, 113 (1933); W. W. Sm. et Forrest, *ibid.*, liv, 22 (1929), and in Notes Roy. Bot. Gard. Edin., xvi, 13 (1928). *P. Dickieana* Watt var. *Pantlingii* W. W. Sm. et Forrest, *ibid.*, xiv, 39 (1923); Smith et Ward, *ibid.*, xv, 88 (1925). *P. Pantlingii* King in Journ. As. Soc. Beng., lv, 228, t. 9 (1886); Pax, *l.c.*; Balf. f. in Journ. Roy. Hort. Soc., xxxix, 158 (1913).

This very distinct species was found in 1848 by Sir Joseph Hooker in the Lachen Valley, Upper Sikkim, but was not described until 1882 and at that date no further material had been secured. It is local in Sikkim and never in profusion. Additional records from Sikkim are from the Lachen district, but in recent years it has been found plentifully in Bhutan, S.E. Tibet, and just within the boundaries of N.W. Yunnan and N.W. Burma. It grows in moist alpine meadows at elevations of 4000–5000 m. Though clearly within the section it is the most aberrant member. The lobes of its corolla are patent and not in line with the tube; the throat and inner part of the corolla-tube are markedly hairy; the flowers show great variation in colour, but without suggestion of hybridity; both heteromorphic and homomorphic conditions occur. It would therefore offer material for an interesting study if amenable in cultivation, but so far seedlings have never been brought to the stage of flowering. In autumn when in fruit there is a resemblance to *P. Valentiniana* and to *P. Kingii*, but the seeds are distinct.

In 1886 King described *P. Pantlingii* which, in view of the material now available, must be regarded as at most only a 1–2-flowered form of *P. Dickieana*. Even in the original Hookerian collections are specimens quite in conformity with *P. Pantlingii* as well as others agreeing with Watt's figure of *P. Dickieana*. In view of the wide distribution it is to be expected that variations occur, but none of these, dealt with later, have any claim to specific status.

P. Dickieana is a perennial with a short but firm rootstock girt above with numerous small scale-leaves. Leaves tufted, 2–7 cm. long, including the short winged petioles which may lengthen later to equality with the blade, 3–10 mm. broad, elliptic-obovate to oblanceolate, more or less acute at the apex, cuneate below, subentire or minutely and remotely denticulate at the margin, cartilaginous, foveolate-punctate, efarinose, with nerves obscure except midrib. Scape usually 8–20 cm. high, bearing an umbel of 1–6 drooping flowers, yellow, white, mauve, violet or purple, usually with yellow eye; these variations in colour often occur in the same mass of plants, but may be localised; bracts linear or filiform, slightly shorter than the stout pedicels which are 2–7 mm. long, lengthening in fruit up to 2·5 cm. and becoming erect. Corolla exannulate, fully 2 cm. long; expanded limb reaching 2–3 cm.; tube nearly twice as long as calyx, hairy at the mouth and within; lobes obcordate to elliptic or oblong, deeply bilobulate at the apex. In pin-eyed flowers style 7–8 mm. long, stamens set 4 mm. above base of corolla-tube; short style 2 mm. long; homomorphic flowers have been found occasionally. Capsule equals calyx. Seeds 1 mm. in diameter, cuboidal, 4–5-angled, smooth.

The type specimen is in the Kew Herbarium and the species is thus represented in Edinburgh:

SIKKIM. Lachen Valley (*Hooker*, 13—*cotype*); San Ku (*King's collector*, s.n.); Lang-mang-nang-go (*Pantling*, s.n.); Tangu (*Younghusband*, 5); Eumtso La (*Smith and Cave*, 1604, 1610).

BHUTAN. Me La (*Ludlow and Sherriff*, 401, 443); Milakatong La (*L. and S.*, 652).

S.E. TIBET. Doshong La (*Ward*, 5867, 5869); Se La (W. 11595); Salwin–Kiu-Chiang divide (*Forrest*, 20271, 20856, 21633, 22814); Kenichunpo (*Rock*, 22170, 22540); Chayul Chu (*Ludlow and Sherriff*, 1537, 2385); Lo Chu, near Molo (*L. and S.*, 1878); Langong (*L. and S.*, 1922); Tsari (*L. and S.*, 2174, 2178); near Langong (*Ludlow, Sherriff and Taylor*, 3866, 3989, 4804, 5262).

N.W. YUNNAN. Salwin–Kiu-Chiang divide (*Forrest*, 19886, 19975).

N.E. UPPER BURMA. N'Maikha-Salwin divide (*Forrest*, 26818, 27292); Imaw Bum (*Ward*, 3389).

P. Dickieana Watt var. **chlorops** W. W. Sm. et Forrest in Notes Roy. Bot. Gard. Edin., xiv, 39 (1923), and *ibid.*, xvi, 13 (1928), and in Journ. Roy. Hort. Soc., liv, 22 (1929).

This dwarf variety has been collected but once in the Tibetan province of Tsarong, on the Salwin–Kiu-Chiang divide, in 1922. The typical plant occurs in the same area. In the variety the leaves are small, 3 cm. long at the most and 3–5 mm. broad; the scape may reach 6 cm., and bears usually 2, sometimes 1 or 3, suberect flowers; the corolla, deep purplish-blue with a green eye, is 1·5–1·7 cm. long and 1·5 cm. across at the apex. It grows in moist stony meadows.

It is represented in Edinburgh by:

S.E. TIBET. West of Chamatong (*Forrest*, 21674—*type*).

P. Dickieana Watt var. **aureostellata** (Balf. f. et Cooper) Fletcher. *P. aureostellata* Balf. f. et Cooper in Notes Roy. Bot. Gard. Edin., ix, 149 (1915); W. W. Sm. et Forrest, *ibid.*, xvi, 13 (1928), and in Journ. Roy. Hort. Soc., liv, 22 (1929).

This vigorous variety is at first sight so different from the Sikkim plant that in its diagnosis as a species it was not correlated with *P. Dickieana* and was placed with some reserve in section Amethystina. In certain habitats in Bhutan the variety attains 35-40 cm. in height, and is further characterised by the white or pale yellow flowers with a deeper yellow star-like centre. It grows in peaty moist turf at 3500–3700 m.

It is represented by:

BHUTAN. Kempe La, Pumthang (*Cooper*, 4137—*type*): Rudong La (C. 4150): Tang Chu Valley (C. 4761): Rudo La (*Ludlow and Sherriff*, 284).

P. Dickieana Watt var. **Gouldii** Fletcher in Journ. Linn. Soc., lii, ined. (1942).

A robust variety like the last. Leaves 8–12 cm. long, 1·5-2 cm. broad, lanceolate; scape 15-23 cm. high with pedicels 1–1·5 cm. long; corolla appears to be deep wine-coloured with suborbicular lobes 5–7 mm. in diameter. It grows at elevations of 4000–4700 m.

The type specimens are at Kew and the species is represented in Edinburgh by:

BHUTAN: Ra La, Minting, Oroling (*Gould*, 559—*cotype*, 580).

P. Faberi Oliver in Hook. Ic. Pl., lviii, t. 1789 (1888); Forbes et Hemsl. in Journ. Linn. Soc., xxvi, 38 (1889); Diels in Engl. Bot. Jahrb., xxix, 521 (1900); Pax in Engl. Pflanzenr. Primulaceae, 115 (1905); Balf. f. in Journ. Roy. Hort. Soc., xxxix, 133, 134, 153 (1913); Smith et Forrest, *ibid.*, liv, 22 (1929), and in Notes Roy. Bot. Gard. Edin., xvi, 13 (1928).

P. Lecomtei Petitm. in Le Monde des Plantes, ix, No. 44, 14 (1907); *P. cylindriflora* Hand.-Mzt. in Anz. Akad. Wiss. Wien Math.-Nat., xxv, 5 (1920), and in Plant. Nov. Sin., 41 (1921).

This remarkable species was first collected on the summit of Mount Omei in the province of Szechwan by Faber and the type is in the Kew Herbarium. Since its discovery it has been seen again on only a few occasions, and its distribution appears to be confined to certain areas in the above province and to the eastern parts of Yunnan. It is found on mountain meadows and pastures at elevations of 2700–3500 m. It is readily distinguished from all the members of the section by its large bracts, its compact inflorescence with short pedicels, and its yellow corolla. It is clear that *P. Lecomtei* is equivalent to *P. Faberi*. As regards *P. cylindriflora*, Dr. Handel-Mazzetti has written to say that his species is the same as *P. Faberi* and that the statement in the original diagnosis as to the violet colour of the flower is a mistake. There is no record of *P. Faberi* in cultivation.

The plant has a short stout rhizome and evidence of basal scales is lacking. Leaves chartaceous, including the short winged petiole 5–8 cm. long, 2–3 cm. broad, oval or oblong or oblanceolate, more or less acute at the apex, tapering at the base, irregularly denticulate at the cartilaginous margin, punctate, efarinose; apart from the prominent midrib nerves inconspicuous. Scape 15–25 cm. high, glandular or faintly farinose at the apex, bearing a compact umbel of 3–10 flowers, secund and more or less pendent; bracts foliaceous, forming an involucre, 6–15 mm. long, 3–4 mm. broad, ovate to ovate-oblong, concave, more or less concealing the calyces; pedicels only 1–2 mm. long. Calyx campanulate, about 7 mm. long, with five prominent ribs, cut to the middle or nearly so into ovate to triangular acute lobes. Corolla yellow, campanulate, about 20 mm. long, 12–14 mm. broad at the apex; cylindric basal part of bell 5–7 mm. long with a gradual expansion above; lobes 4–5 mm. long, obovate to ovate-oblong, entire or slightly emarginate or undulate-erose. In thrum-eyed flowers stamens attached at apex of basal cylinder; style 1 mm. long. Capsule about equal to the calyx. Mature seeds not seen.

The representation in Edinburgh is:

SZECHWAN. Ma-pica Hsien (*Wang*, 22927); Lanba, Lolo Territory (*Handel-Mazzetti*, 1767—*cotype* of *P. cylindriflora*).

E. YUNNAN. Pastures of high plateau of Ta-hai (*Maire*, s.n.); Plateau of Je-Ma-Tchouan (M., s.n.).

P. Kingii Watt in Journ. Linn. Soc. Bot., xx, 9, t. 8A (1882); Hook. f. in Fl. Brit. Ind., iii, 491 (1882); Pax in Engl. Bot. Jahrb., x, 213 (1889); Watt in Journ. Roy. Hort. Soc., xxix, 300, 314, 319 (1904); Pax in Engl. Pflanzenr. Primulaceae, 118 (1905); Craib in Journ. Roy. Hort. Soc., xxxix, 189 (1913); W. W. Sm. et Forrest, *ibid.*, liv, 22 (1929), and in Notes Roy. Bot. Gard. Edin., xvi, 13 (1928); Journ. Roy. Hort. Soc., lxi, 294, Proc. p. cxxxvii (1936); Gard. Chron., Ser. 3, cv, 349 (1939). *P. Gageana* Balf. f. et W. W. Sm. in Notes Roy. Bot. Gard. Edin., ix, 18 (1915); W. W. Sm. et Forrest, *ibid.*, xvi, 13 (1928), and in Journ. Roy. Hort. Soc., liv, 22 (1929).

The first discovery of this plant was in 1878 when Dungboo, Sir George King's collector, obtained it at Natong in the eastern part of the Sikkim Himalaya at an elevation of over 4000 m. In that region it has been found on several occasions since, but it is not common and is apparently local. In recent years it has been recorded from West Bhutan, S.E. Tibet, and the Assam Himalaya, and in the Tibetan station described as very common, covering hundreds of yards of open wet meadows. Its nearest allies are *P. Valentiniana* and *P. odontica*. *P. Gageana*, here reduced to a synonym of *P. Kingii*, comes also from Sikkim and does not differ except in the smaller size and in the more obtuse leaves. These differences are almost certainly accidental and have not been observed again in any subsequent material from that province since the one and only collection in 1886. Like other members of the section this desirable species is a difficult problem in cultivation. Seeds have often been collected, but the resulting young plants generally die before reaching the flowering stage. Plants raised by Lord Aberconway in 1936 received an Award of Merit from the Royal Horticultural Society. It was in flower in Edinburgh in the same year and again in 1939, but did not set seed. It is unlikely that at this date the species survives in any garden.

A perennial plant with a short fairly stout rootstock girt above with a few oblong pointed scales 1–2 cm. long. Leaves, including the short broadly winged petiole, 2-6 cm. long, 0·5-1 cm. broad, elliptic-lanceolate to lanceolate, acute or rarely obtuse at the apex, tapering below, entire or faintly crenulate or remotely denticulate at the somewhat horny margin, cartilaginous, foveolate-punctate, efarinose. Scape 10–20 cm. high, reaching 30 cm. in fruit, carrying an umbel of 2–10 semi-pendent flowers; bracts 3–10 mm. long, filiform; pedicels 5–15 mm. long, slightly puberulous, lengthening but little in fruit. Calyx narrow-campanulate, 6–8 mm. long, 4–5 mm. broad, somewhat 5-angled, divided to one-third up to one-half into triangular subacute lobes. Corolla a dark claret, almost black, finely puberulous within and without, 1·5–1·8 cm. long, bell-shaped; lower tubular portion as long as calyx; expanded upper part 1·5 cm. across at the apex, cut into elliptic or oblong lobes, 5 mm. long, entire, retuse or slightly erose; annulus lacking or very faintly developed. In thrum-eyed flowers stamens set 8–9 mm. from base of corolla; style 2 mm. long. Long style slightly exceeding the calyx. Capsule ovoid, usually equalling calyx but may be half as long again. Seeds about 1·5 mm. in diameter, ovoid, somewhat flattened, sometimes angled, smooth and black; when not quite mature with a delicate fringing aril.

The species is thus represented in Edinburgh:

Sikkim. Natong (*Dungboo*, 4374– *type* ex Herb. Watt); Sherao-thang (*Smith*, 3394); (*Cave*, 6183, 7132); Changu (C. 2027); (*Ribu*, 27); Nathu La (*Bailey*, s.n.).

Bhutan. Charithang (*Ludlow and Sherriff*, 40, 3570).

Assam Himalaya. Dirang Dzong (*Ward*, 13701).

S.E. Tibet. Tsari Suma, Langong (*Ludlow, Sherriff and Taylor*, 5570, 6595).

P. odontica W. W. Sm. in Notes Roy. Bot. Gard. Edin., xix, 199 (1937); Ludlow in The Himalayan Journal, x, fig. in natural colour facing p. 1 (1938).

This species is known almost solely from the collections made in 1936 by Ludlow and Sherriff in S.E. Tibet. It is reported as common in certain areas on open hillsides and steep grassy slopes at elevations of 4300–5000 m. In its general aspect it is akin to *P. amethystina* and *P. Valentiniana*. It resembles both in the structure of calyx and corolla, but differs markedly in its foliage and in its seeds. Plants have been raised from seed by Mr. R. B. Cooke of Corbridge and brought to the flowering stage in October 1938. This is the only record of its successful cultivation. His plants were still alive in 1942.

A beautiful plant with a short stout rhizome clothed above with ovate to lanceolate cartilaginous scales 2–5 cm. long and passing gradually to the ordinary leaves. The latter, including the short winged petiole, 5–7 cm. long, 1·5–2·5 cm. broad, oblanceolate or lanceolate or elliptic, acute or subacuminate at the apex, gradually tapering below, very strongly and irregularly dentate with the teeth patent, of firm papery consistency, foveolate-glandular, efarinose, glabrous. Scape 9–12 cm. high, minutely puberulous, carrying an umbel with usually 3–10 more or less pendulous fragrant flowers; bracts 4–10 mm. long, filiform; pedicels 1–2 cm. long, scarcely lengthening in fruit, with very fine hairs suggestive of farina. Calyx cupular, about 7 mm. long, dull greenish-red, with very minute hairs, divided to about the middle into lanceolate or subtriangular acute lobes. Corolla campanulate, 1·5–1·7 cm. long and broad, a deep rich claret, annulate with a bright orange eye; cylindric basal part of bell very short but abruptly expanded above; lobes 6 mm. long, obovate, entire or subentire at the apex. In pin-eyed flowers stamens set 2 mm. from base of tube; style 6 mm. long. Capsule equals calyx, dehiscing by apical valves. Seeds 1 mm. in diameter, somewhat flattened 4–5-angled, smooth.

The type specimen is in the British Museum and the representation in Edinburgh is:

S.E. TIBET. Chickchar, Tsari (*Ludlow and Sherriff*, 2153—*co-type*, 2484); Takar La, W. Tsari (*L. and S.*, 2068).

P. silaensis Petitm. in Bull. Herb. Boiss., Sér. ii, vii, 524, fig. 3, III (1907); W. W. Sm. et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 13 (1928), and in Journ. Roy. Hort. Soc., liv, 22, fig. 14 (1929).

This species was collected by Soulié in 1895 on Mount Sila which lies on the Mekong-Salwin divide. The type material (*Soulié*, 1130) on which Petitmengin based his description in 1907 is in the Paris Herbarium. Since that date much fine material has been obtained by Forrest, Ward, Farrer, and Rock. In its distribution it does not extend very far into Yunnan, but reaches the frontier areas of Burma, S.E. Tibet, and the Assam Himalaya. Its nearest ally is *P. amethystina*, from which its slender habit and small flowers readily distinguish it. It is a plant of moist and sometimes stony ground in peaty alpine meadows at 4000–4800 m. It is a matter of regret that so dainty a plant has never been introduced into cultivation. Seeds have been collected more than once, but did not germinate.

A fragile plant with a very slender rootstock, many individuals often growing together in a dense tuft. Leaves with slender winged petiole half as long as or as long as blade; latter usually 1–2 cm. long, 0·5–1·5 cm. broad, often as broad as long, obovate to oblong-ovate, usually rounded, rarely somewhat pointed at the apex, cuneate at the base, minutely but sharply denticulate at the somewhat horny margin, chartaceous in the dried state, glandular-foveolate, efarinose, glabrous. Scape usually about 8 cm. high but varying from 2–12 cm., with 1–5 fragrant semi-pendulous flowers; bracts linear or linear-lanceolate, about 2 mm. long, acute; pedicels slender, 1–5 mm. long. Calyx campanulate 2–4 mm. long, as broad as long, dull purple, divided to about the middle into ovate or lanceolate lobes, obtuse or acute and sometimes apiculate. Corolla campanulate, described as pale purplish-mauve, rose-magenta and deep blue-purple, 8–10 mm. long, 10–13 mm. broad; bell with short cylindric base abruptly dilated above; lobes about 3 mm. long and broad, entire, with or without a mucronate point, or emarginate with a mucro in the sinus or sometimes erose-denticulate. Stamens 1 mm. long; long style measures 4 mm., short one 1 mm. Capsule equals the calyx or slightly exceeds it, with pedicels elongating and becoming more or less upright. Seeds scarcely 1 mm. in diameter, ovoid, vesicular-surfaced.

In Edinburgh Herbarium the species is thus represented:

Yunnan. On the Mekong-Salwin divide (*Forrest*, 1806a, 13252, 19516); (*Rock*, 17030); (*Ward*, 93); Mekong-Yangtze divide (F. 25552, 25905); Bei-ma Shan (F. 14462); Fuchuan Shan (F. 30221); Kaakerpo (R. 22988, 23573).

N.E. Upper Burma. M'Maikha-Salwin divide (*Forrest*, 24560, 26866); Chimi-li (*Farrer*, 1208); Chawchi Pass (*Farrer*, 1695).

S.E. Tibet. Tsarong, on the Salwin-Kiu-Chiang divide (*Forrest*, 18868, 22932).

Burma-Tibet Frontier. Seinghku Valley (*Ward*, 6940, 7002, 7590).

Assam Himalaya. Mishmi Hills, Delei Valley (*Ward*, 8401).

P. Valentiniana Hand.-Mzt. in Anz. Akad. Wiss. Wien Math.-Nat., lix, 249 (1922); Smith in Notes Roy. Bot. Gard. Edin., xiv, 53 (1923); Smith et Ward, *ibid.*, xv, 69 (1926); Smith et Forrest, *ibid.*, xvi, 13 (1928), and in Journ. Roy. Hort. Soc., liv, 22 (1929); Sherriff et Taylor in Quart. Bull. Alp. Gard. Soc., vii, 228, fig. p. 226 (1939).

Dr. Handel-Mazzetti was the first to discover this species in the extreme N.W. corner of Yunnan. It appears to be more common in S.E. Tibet and occurs also within the frontiers of Burma. In the original diagnosis it was compared (*ex descript.*) with *P. silaensis*, from which it differs in the stout rootstock and basal scales, as also in its leaves, size of flower and seeds. Its nearest ally is *P. Kingii*, to which it shows a strong resemblance but diverges in the cupular calyx and in the shape and hairiness of the corolla-tube. It grows in open peaty alpine meadows at an elevation of 4000–5000 m. Its seeds have germinated in cultivation, but there is no record of the plant reaching flowering stage.

The plant has a short thick rootstock girt above with broad oval pointed scales about 1 cm. long. Leaves with winged petiole equal to half blade or more, often not fully developed when scape is in full flower; blade 1·5–3 cm. long, 0·5–1 cm. broad, usually obovate to oblanceolate, pointed or subobtuse at the apex, cuneate at the base, undulate-denticulate at the margin, of fleshy consistency, foveolate-punctulate, efarinose, glabrous. Scape 5–10 cm. high, usually carrying 1–2, very occasionally 3–5, very attractive nodding flowers; bracts filiform, 2–8 mm. long, often inserted at different levels; pedicels 2–10 mm. long. Calyx cupular, 3·5–5 mm. long and broad, tinted with purple, divided almost to the middle into ovate-triangular lobes, usually obtuse and 1-nerved. Corolla described as varying from light to deep wine-crimson or deep cherry-red, 14–16 mm. long and as broad at apex; cylindrical basal part of bell very short, about 1 mm., with abrupt expansion upwards; lobes 6–8 mm. long and broad, rounded to suboblong, entire or undulate or slightly emarginate, sometimes with a mucro in the sinus; inside of tube furnished with a few whitish hairs. In pin-eyed flowers stamens set 2·5 mm. above base of corolla; style 7 mm. long. In thrum-eyed flowers stamens placed 4–5 mm. above base of tube; style reaches 2 mm. Capsule equals calyx or slightly exceeds it, apparently very persistent as one collector reports it sometimes full of seed in the ensuing spring. Seeds 1 mm. in diameter, not vesicular-surfaced, ovoid to angular-ovoid, not unlike those of *P. Kingii* but not the same.

The plant was named after Père Valentin, missionary in Yunnan, and the type is in the Vienna Herbarium. The representation in Edinburgh is:

N.W. Yunnan. Salwin–Kiu-Chiang divide (*Forrest*, 25571).

S.E. Tibet. Salwin–Kiu-Chiang divide (*Forrest*, 20000, 20850, 21792, 22931); Doshong La (*Ward*, 5859); Upper Salwin west of Champutong (*Rock*, 22529); on the Salwin-Irrawadi divide (R. 21931); Singo Samba, Lo Chu Valley, near Molo (*Ludlow and Sherriff*, 1885); near Langong (*Ludlow, Sherriff and Taylor*, 3953, 5229, 5569); near Paka (*L., S. and T.*, 5866).

N. Burma. Chawchi Pass (*Farrer*, 1723).

P. Virginis Lévl. in Le Monde des Plantes, No. 92, 1 (1915); W. W. Sm. et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 13 (1928), and in Journ. Roy. Hort. Soc., liv, 22 (1929). *P. leimonophila* Balf. f. in Notes Roy. Bot. Gard. Edin., ix, 25 (1915). ? *P. petrophyes* Balf. f., *l.c.*, 33 (1915).

This plant is known only from the collections made in June 1911 by E. E. Maire on the Io-chan plateau in Eastern Yunnan at an elevation of 3300 m. Part of his material was sent to Léveillé and part was purchased by Edinburgh. Two diagnoses were published early in 1915 and almost at the same time. The name given by Léveillé has priority. It should be noted that Maire's handwriting led Balfour to place the plant in Hunan which is an error. The nearest ally is *P. amethystina*, from which it can be distinguished by the lanceolate acute leaves, by the elongate coloured calyx and by the oblong corolla-lobes. It has not been in cultivation.

The plant has a short fairly stout rootstock girt above with remains of withered leaves and persistent leaf-bases. Leaves, including the short broadly winged petiole, 3–6·5 cm. long, 0·5–1·4 cm. broad, lanceolate, acute or acuminate at the apex, cuneate below, remotely denticulate at the somewhat horny margin, subcoriaceous, foveolate-punctate, efarinose. Scape 12–22 cm. high, bearing a more or less unilateral umbel of 2–6 nodding flowers; bracts 4–6 mm. long, linear-lanceolate; pedicels 5–7 mm. long, finely puberulous. Calyx almost cylindric, 5–7 mm. long, 2–3 mm. broad, 5-angled, covered with a minute pubescence, coloured almost the same as corolla, divided to nearly the middle into narrow lanceolate lobes often with mucronate tips. Corolla according to Maire is "bleu de prusse"; tubular lower part as long as calyx; bell-shaped part 10 mm. long, 13 mm. broad at apex, cut into narrow-oblong lobes, 5 mm. long, subtruncate and emarginate at the apex. In pin-eyed flowers style 6–7 mm. long; stamens set about 2 mm. above base of tube; annulus 2·5 mm. above insertion of stamens. In thrum-eyed flowers stamens set at mouth of cylinder; style 1 mm. long; no annulus. Capsule not seen.

Maire collected at the same time and at the same place on rocky ground certain dwarfer plants which do not fit exactly with *P. Virginis*. Balfour (*l.c.*, 33) regarded these as possibly an alpine equivalent of *P. Virginis* and gave the name *P. petrophyes*. The leaves are smaller, 2–3 cm. long, not exceeding 5 mm. broad; scape at most 10 cm.; pedicels shorter than the bracts; corolla 10 mm. long, 5–7 mm. broad at apex. The available material of this and also of *P. Virginis* is too meagre for a just comparison. Further collections of both are needed, and meanwhile it is better to consider Maire's plants as constituting but one unit.

The species is thus represented:

E. YUNNAN. In pastures of Io-chan plateau (*Maire*, s.n.—*type* and also *type* of *P. leimonophila*): on rocks in the same area (*Maire*, s.n.—*type* of *P. petrophyes*).

THE GENUS PRIMULA: SECTION MINUTISSIMAE. By W. WRIGHT SMITH and H. R. FLETCHER.

(Read 23rd April 1942.)

As the name well indicates, the section contains a number of dwarf species, including possibly the majority of the pygmy plants to be found in the genus. The section was first instituted by Pax (Engler's Bot. Jahrb., x, 202 (1889)) for three Himalayan species which he separated by their stoloniferous habit from his section Tenellae, also a group of dwarf plants with usually one flower or at most three. The stoloniferous habit cannot now be regarded as a discriminating character between the two sections, for *P. flagellaris*, a close ally of *P. tenella*, produces stolons freely, as does to some extent *P. bella*. Neither can the leaf characters nor the geographical distribution give sanction to separation. Consequently, of the seven members of Pax's section Tenellae five can be transferred to Minutissimae: the remaining two go to two other sections. Even allowing for this transference, the content of Minutissimae has been more than doubled since the publication of Pax's Monograph in 1905. All dwarf species are not referred to this section. Very small plants occur in such sections as Soldanelloideae, Nivales, and Farinosae. But in these cases it is presumed that their association with these sections is more or less proved on phyletic grounds. The Minutissimae consequently represent a collection of species of which the affinity with other sections is in most cases doubtful or obscure. The result is that the species within the section cannot be considered as entirely homogeneous. On the other hand, they show certain degrees of relationship and are not merely more or less isolated units. The only section which can be regarded as closely allied is Farinosae, and it is arguable that some four or five species could be transferred there. But even in so accommodating a section as the Farinosae these same species would find no near kin. In keeping with their small stature, the species with a few exceptions are almost invariably 1-flowered. Solitary flowers are found elsewhere in the genus but the affinity of the species concerned is determinable. The heterogeneity of the section, however, is not to be exaggerated. In addition to the habit and the tendency to solitary flowers, it must be noted that in most cases the corolla-tube is 2–3 times the length of the calyx, that the corolla-lobes are invariably cleft or deeply emarginate and that the shortly cylindric fruit more or less equals the calyx (where fruit is available for inspection). On these criteria the species can be best assembled in one single section—a preferable course to making several new and very small sections.

With this inclusion in great part of Pax's section Tenellae, it is also necessary to add Balfour's section Bella. The one criterion which marks out that section is the occlusion of the throat of the corolla by a dense pompon of hairs. Stapf, when dealing with *P. tenella* in Bot. Mag., t. 8881B, commented on its general resemblance to *P. bella* and expressed the view that the two were probably closely allied and should find themselves in the same section. The greater villosity in *P. bella* he regarded as only a matter of degree. Although the presence of the pompon in certain species affords a ready means of recognition, an examination of the aggregate of *P. bella* and its associates shows that this feature is not invariably reliable. The other characters of the section Bella are in general accord with those of Minutissimae and the sum of the evidence confirms the view taken by Stapf.

The species are not alike in habit. Some show a low mat-like growth, with both leaves and flowers rising hardly above the level of the soil. The majority form neat rosettes as in so many Primulas and carry their flowers more or less above the leaves. There is no vigorous rhizomic development indicating that the individual plant has a long life. In many cases this is compensated by the production of stolons. This is seen in the prostrate species such as *P. minutissima*, but has been observed also in *P. tenella* and reaches in *P. flagellaris* a quite remarkable evolution, comparable to what occurs in many Saxifrages (e.g. *S. sarmentosa*). White or yellow farina occurs freely on one half of the species, and the section for diagnostic purposes can be divided into efarinose and farinose groups. This division is a matter of convenience and has no phyletic sanction. It may be noted, however, that the farinose half of the section includes the few species which appear to approximate to the Farinosae. The leaves of the section show a high degree of non-conformity in size, in consistency and in shape. The margins may be finely serrate or grossly so, dentate or denticulate, or again more or less entire. It follows that no general description of the leaf can be given as characteristic of the section. The petiole may be well developed and distinct from the lamina, but again may be quite short or almost lacking. As a rule the scape is short, sometimes almost absent, but is well developed in some of the members. The flowers are in most cases solitary (exceptionally two or even three), but in *P. glandulifera*, *P. pusilla*, and *P. Heydei* they are usually more numerous. The pedicels are normally very short making the flowers more or less sessile, but in a few species the pedicels are fairly well developed. Bracts when present are never saccate nor auricled. The calyx in comparison with the corolla is usually small, but in a few species such as *P. pusilla*, *P. Geraldinae*, *P. rhodochroa*, and *P. Walshii*, it is equal to the corolla-tube or slightly shorter. In most cases the corolla-tube exceeds the calyx twice or even three times. The lobes are usually patent, but appear to be more or less erect in *P. subularia* and *P. praetermissa*; they are in all cases deeply emarginate or cleft into narrow lobules. The capsules conform to the narrow cylindric fruits of most Farinosae and are more or less equal in length to the calyx. The section is entirely Asiatic, and with the exception of three species is restricted to the Himalaya and the adjoining parts of Southern and South-Eastern Tibet. *P. Walshii* is found in the Eastern Himalaya, in S.E. Tibet, and also in West China in the province of Szechwan. *P. bella* and its subspecies are widespread in S.W. China and the adjoining borders of Tibet and Burma, where *P. moschophora* is also found. Some species are confined to the Western Himalaya and some to the Eastern side. There is no species extending throughout the Himalayan range.

Few of the species have been in cultivation. *P. pusilla*, *P. tenella*, and *P. bella* have been figured in the Botanical Magazine. In recent years *P. reptans* has been introduced and brought to flowering stage. None of the species is likely to prove amenable in gardens.

There is little or nothing known of the cytology of the section. The only species examined is *P. reptans* with chromosome number $2n = 22$. The chromosomes are of very small size and in Bruun's opinion suggest an approach to what is found in some members of the Farinosae. (Bruun: Cytological Studies in Primula, 1932, p. 48, 129.)

As far as our present knowledge goes the species in this section are as follows:—

Subsection Eu-minutissimae.

P. annulata *Balf. f. et Ward.*
P. flagellaris *W. W. Sm.*
P. Geraldinae *W. W. Sm.*
P. glandulifera *Balf. f. et W. W. Sm.*
P. Heydei *Watt.*

P. minutissima *Jacquem.*
    P. Saundersiana Royle mss.
    P. Stracheyi Hook. f.—*pro parte.*
P. muscoides *Hook f.*
P. praetermissa *W. W. Sm.*
P. reptans *Hook. f.*
    P. Stracheyi Hook. f.—*pro parte.*
P. rhodochroa *W. W. Sm.*
P. rimicola *W. W. Sm.*
P. spathulifolia *Craib.*
    P. minutissima Jacquem. var. *spathulata* Hook. f.
    ? *P. melichlora* Balf. f. et W. W. Sm.
P. Stirtoniana *Watt.*
P. subularia *W. W. Sm.*
P. tenella *King.*
P. tenuiloba (*Hook. f.*) *Pax.*
    P. muscoides Hook f. var. *tenuiloba* Hook. f.
P. Waddellii *Balf. f. et W. W. Sm.*
P. Walshii *Craib.*
    P. petrocharis Pax et K. Hoffm.

SUBSECTION BELLA.

P. barbatula *W. W. Sm.*
P. bella *Franch.*
    Subsp. P. Bonatiana (Petitm.) *W. W. Sm. et Forrest.*
        P. Bonatiana Petitm.
        P. stragulata Balf. f. et Forrest.
    P. coryphea (Balf. f. et Ward) *W. W. Sm. et Forrest.*
        P. coryphea Balf. f. et Ward.
    P. cyclostegia (Hand.-Mzt.) *W. W. Sm. et Forrest.*
        P. cyclostegia Hand.-Mzt.
    P. nanobella (Balf. f. et Forrest) *W. W. Sm. et Forrest.*
        P. nanobella Balf. f. et Forrest.
    P. sciophila (Balf. f. et Ward) *W. W. Sm. et Forrest.*
        P. sciophila Balf. f. et Ward.
P. moschophora *Balf. f. et Forrest.*
    P. bella Franch. subsp. *moschophora* W. W. Sm. et Forrest.
P. occlusa *W. W. Sm.*
P. pusilla *Wall.*
    Androsace primuloides D. Don.
    Androsace primulina Spreng.
    Primula humilis Steud.

KEY TO SUBSECTIONS.

SUBSECTION I (Eu-Minutissimae).
Corolla-throat glabrous or with a few scattered hairs.

SUBSECTION II (Bella).
Corolla-throat closed with projecting pompon of hairs. (See p. 255.)

KEY TO THE SPECIES.

SUBSECTION I (EU-MINUTISSIMAE).

A. Leaves efarinose (some are obscurely farinose under lens):—
B. Corolla-tube = 2 times calyx or more:—
C. Leaves ± entire; scape 1-flowered:—
D. Leaves linear, entire . . . . *subularia*
DD. Leaves oblanceolate, with occasionally 1–2 teeth . *praetermissa*
CC. Leaves serrate or denticulate:—
D. Scape 1-flowered, with rare exceptions:—
E. Corolla-tube 4–5 mm. long; E. Himalaya . . . *muscoides*
EE. Corolla-tube 8–10 mm. long:—
F. Corolla-lobes obcordate, as broad as long:—
G. Lamina ± 1 cm., twice as long as broad; E. Himalaya *Stirtoniana*
GG. Lamina 2–4 mm., as broad as long; W. Himalaya *reptans*
FF. Corolla-lobes very narrow, much longer than broad:—
G. Lamina glabrous, serrate throughout; corolla hairy outside . . . . *tenuiloba*
GG. Lamina finely pubescent, serrate at apex; corolla glabrous outside . . . . *Waddellii*
DD. Scape 2–4-flowered; flowers sessile; W. Himalaya . *glandulifera*
BB. Corolla-tube = 1–1¼ calyx:—
C. Flowering scape much longer than leaves, 1-flowered; calyx obscurely farinose; W. China . . . . . . *annulata*
CC. Flowering scape immersed in leaves, 1–4-flowered; calyx scabrid-glandular; E. Himalaya, Tibet, W. China . . . *Walshii*
AA. Leaves obviously farinose:—
B. Corolla-tube = 2–3 times calyx:—
C. Scape ± elongate; flowers well above leaves:—
D. Scape 1(–2)-flowered; leaves generally obovate to spathulate; E. Himalaya, S.E. Tibet:—
E. Farina white; corolla throat and inside of tube hairy:—
F. Very long bare stolons; scape ebracteate. . . *flagellaris*
FF. Stolons absent or very short and leafy; solitary characteristic bract below calyx . . . . . . *tenella*
EE. Farina yellow; corolla throat and inside of tube glabrous *rimicola*
DD. Scape 2–8-flowered; leaves lanceolate acuminate; W. Himalaya . . . . *Heydei*
CC. Scape 0 or very short; flowers immersed in leaves:—
D. Leaves 10–20 mm., spathulate with rounded apex, entire or serrulate; E. Himalaya . . . . . . *spathulifolia*
DD. Leaves 5–10 mm., narrow with acuminate apex and a few remote teeth; W. Himalaya . . . . . *minutissima*
BB. Corolla-tube = calyx; S.E. Tibet:—
C. Farina white; 1–4-flowered; corolla 5–15 mm. diameter . *rhodochroa*
CC. Farina yellow; 1(–2)-flowered; corolla 1·5–2 cm. diameter . *Geraldinae*

P. annulata Balf. f. et Ward in Notes Roy. Bot. Gard. Edin., ix, 6 (1915–16): Smith et Forrest, *ibid.*, xvi, 23 (1928), and in Journ. Roy. Hort. Soc., liv, 31 (1929).

Nothing is known of this rare species beyond its discovery in 1913 by Kingdon Ward on a limestone peak at 4700 m. in N.W. Yunnan near A-tun-tsu on the borders of S.E. Tibet. The area has been visited before and since that date by other explorers questing for Primulas, but there is no record of this plant in their collections. In the original description a general resemblance to *P. yunnanensis* and *P. bella* is suggested without implying any close affinity. It cannot be associated with either of these species. Its foliage is comparable with that of *P. Stirtoniana*. The plant is apparently efarinose but farini-potent glands are numerous on the leaves. Although not akin to any other member of the Minutissimae, its assignment there is more satisfactory than in the Farinosae.

A dwarf efarinose plant with a short comparatively thick rhizome and with the base clothed with the withered remains of old leaves. Leaves in a rosette, spathulate to oblong-spathulate, 1–1·5 cm. long including the petiole, 4–5 mm. broad, rounded or obtuse at the apex, gradually tapering into the broadly winged petiole which in fully developed leaves is as long as the lamina, regularly serrate to serrate-lobulate at the margin, copiously covered on both surfaces with potentially farinose glands giving the leaf a minute scabridity; the midrib and sometimes the lateral nerves are prominent on the lower surface. Scape slender, glandular-puberulous, up to 3·5 cm. high, with a single terminal monomorphic flower and with a pair of unequal lanceolate or subulate bracts, 2–2·5 mm. long, inserted a little below the calyx; pedicel puberulous, about 2 mm. long. Calyx green, campanulate, puberulous, 3·5 mm. long, cleft to the middle into triangular to oblong deltoid lobes, obtuse or acute and sometimes slightly toothed at the apex. Corolla violet; tube up to 4 mm. long and therefore only slightly longer than the calyx, minutely puberulous within and with a prominently lobulate annulus; limb about 8 mm. in diameter with obcuneate, deeply emarginate lobes up to 3 mm. long. Stamens, with anthers 0·5 mm. long, inserted near the middle of the corolla-tube and surrounding the globular stigma. Capsule about as long as the calyx, dehiscing by apical teeth which later extend almost to the base.

The Edinburgh Herbarium has the following:—

N.W. Yunnan. A-tun-tsu (*Ward*, 511—*type*).

P. flagellaris W. W. Sm. in Rec. Bot. Surv. Ind., iv, 219 (1913); Smith et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 28 (1928), and in Journ. Roy. Hort. Soc., liv, 29 (1929).

This species is readily distinguished by the possession of long leafless flagellate stolons, terminated by a small leafy bud. It was first discovered in 1909 by Smith and Cave in Sikkim near the entrance to the Zemu Valley, on a hill at an elevation of 4000 m. to the west of Lachen. Collected in the second week of August, too late for satisfactory flowers, the material justified description only by reason of the remarkable stolons. It has not been found again in Sikkim, but adequate collections of what is undoubtedly the same plant have been made in recent years by Ludlow and Sherriff in Bhutan. These specimens show conclusively that *P. flagellaris* is a very close ally of *P. tenella* which has a larger flower, a characteristic bract immediately below the calyx, and no elongate stolons. Ludlow and Sherriff note that specimens of *P. flagellaris* taken in early August show the plantlets at the ends of the stolons as mostly well rooted. Plants of *P. tenella* taken in August and September show no stolons, though the species is sometimes slightly stoloniferous. There is a strong resemblance between the two in the shape of the corolla and in the hairiness on the inside of the corolla-tube.

P. flagellaris is a very small tufted plant with a short rhizome, enclosed at the base with withered leaves of the preceding year and developing from August onwards leafless flagellate stolons 5–10 cm. long, each with a tiny rosette at the end; the flower is as large or larger than the rest of the plant. It grows singly or in little patches on cliffs amidst moss. Leaves white-mealy below with occasional flecks on the upper surface; lamina 5–20 mm. long, 3–8 mm. broad, usually obovate or oblanceolate, more or less rounded at the apex, with a cuneate base, dentate or serrate mostly in the upper half; petiole short but sometimes equalling the blade. Scape mealy, erect, 2–3 cm. in height, usually with a single flower, but two-flowered plants are reported in the field as not infrequent; bracts appear to be entirely absent even in two-flowered specimens; the mention of a bract in the original description, based on a very imperfect flower, is probably an error. Calyx 3–8 mm. long, tubular-campanulate, cut to the middle or to two-thirds, more or less mealy; lobes linear-oblong, usually acute, less often somewhat obtuse. Corolla funnel-shaped, with a flat limb 1–1·5 cm. across, usually blue-violet with sometimes a shade of red in it; eye white; lobes obcordate and emarginate; tube 8–12 mm. long, slenderly cylindrical below, expanded above, with an occasional fleck of meal, finely hairy inside. Anthers scarcely exceeding 1 mm., in thrum-eyed flowers inserted a little above the middle of the tube, in pin-eyed about 3 mm. from the base. The longer style is some distance below the corolla-mouth and the shorter style is within the calyx. The subglobose ovary matures into a shortly cylindric capsule usually a little less than the calyx.

P. flagellaris flowered at Edinburgh (*L. and S.*, 3052) in 1939, but did not persist. The type sheet is in the Calcutta Herbarium and the species is represented in Edinburgh by the following:—

SIKKIM. Zemu Valley (*Smith and Cave*, 2631—*cotype*).

BHUTAN. Chendibi (*Ludlow and Sherriff*, 3052, 3141, 3326, 3520); Tang Chu, Ritang (*L. and S.*, 3203, 3231, 3368).

P. Geraldinae W. W. Sm. in Trans. Bot. Soc. Edin., xxxiii, 116 (1941).

This recently discovered species finds its only near ally in *P. rhodochroa*. Both have obvious farina and a calyx more or less equalling the corolla-tube. The chief distinction lies in the foliage, which in *P. Geraldinae* is of firmer texture, with obscure serrations and heavily covered on the underside with yellow farina. The flower is somewhat similar to that of its ally but distinctly larger and with narrower calyx-teeth. The type is in the British Museum.

A very attractive dwarf species with a flower as large as the rest of the plant. It has been found on three occasions—in 1938 by Ludlow, Sherriff and Taylor in S.E. Tibet, growing in wet moss on sheer cliff faces at an elevation of 3800–4600 m. There is a short stout rhizome covered above with the withered remains of old leaves, as is so frequently the case with these high alpine Primulas. Leaves in a small compact rosette, membranous, elliptic or obovate or spathulate, including the petiole usually 1·5–2·5 cm. long, 3–5 mm. broad, obtuse or rounded at the apex, gradually narrowed into a winged petiole which more or less equals the blade, finely serrulate on the margin, with a sprinkling of farinose glands above but densely clothed below with yellow farina so that the 4–5 pairs of nerves are almost hidden. Flowers solitary or a pair; scape at first quite concealed among the leaves but later at most 2·5 cm. tall, yellow-farinose especially towards the apex; bracts linear, up to 5 mm. long, farinose; pedicels 2–3 mm. long. Calyx green, dusted with farina on the outside and thickly yellow-farinose on the inside, 6–8 mm. long, with 5 conspicuous nerves, lobed to the middle or slightly below, the lobes being lanceolate to oblong-lanceolate, obtuse or occasionally obscurely 3–toothed at the apex. Corolla dark lilac, turning darker in the centre, mauve or rich wine-red; tube as long as or slightly longer than the calyx, palest lilac on the outside and covered on the inside and at the throat with yellowish farina, giving the appearance of a yellow eye; limb up to 2 cm. in diameter with broadly obcordate lobes 7 mm. long and broad and deeply emarginate. Stamens in thrum-eyed flowers inserted at the throat of the corolla and half-way up the corolla-tube in pin-eyed flowers. Style barely as long as the corolla-tube in long-styled flowers and half as long as the tube in short-styled flowers. Capsule slightly longer than the calyx, dehiscing by apical teeth.

It is represented in the Edinburgh Herbarium by the following:—

S.E. TIBET. On the Lo La, Pachakshiri (*Ludlow, Sherriff and Taylor*, 3640—*cotype*, 3756); on the Chubumbu La (*L., S. and T.*, 3987). Flowered under 3640, Edinburgh, 1939, but died.

P. glandulifera Balf. f. et W. W. Sm. in Notes Roy. Bot. Gard. Edin., ix, 20 (1915-16); Smith et Forrest, *ibid.*, xvi, 28 (1928), and in Journ. Roy. Hort. Soc., liv, 29 (1929).

This rare species, collected in Kumaon, N.W. Himalaya, on two occasions nearly sixty years ago, has apparently not been seen since. The material is very meagre and requires to be supplemented before an adequate diagnosis is possible. In the original description Duthie's locality for No. 3137, as quoted from his written note, is incorrectly stated. Reference to Report Gov. Bot. Gard. Sahāranpur, 37 (1885), shows that Duthie obtained his specimens above the village of Napalcha, in the Kutti Valley, Byans. J. R. Reid, who accompanied Duthie on the first occasion (and incidentally found *P. Reidii*), secured the second gathering in 1886 above Dudhpani, Kumaon, at an elevation of about 4300 m. Neither Duthie nor Reid nor later on Watt, all well acquainted with the West Himalayan Primulas, recognised the plant as equivalent to any known species. Watt placed it near *P. Heydei*, and that opinion seems justified. *P. glandulifera* differs from that species in that it is glandular-puberulous and not farinose, while the leaves are of quite another shape. The glandular pubescence appears to be of the farini-potent type, and under certain conditions it would not be surprising if the plant became farinose. The size and structure of the flower are as in *P. Heydei* and *P. minutissima*. Its rediscovery by botanists visiting Kumaon is much to be desired.

A dwarf tufted plant at most 2·5 cm. tall, efarinose, but everywhere covered, except for the corolla, with a glandular-puberulousness. The base of the plant is girt by the withered remains of last year's leaves. Leaves up to 2 cm. long, usually with the lamina rather shorter than the petiole, elliptic to oblong-elliptic to obcuneate, 5–7 mm. broad, rounded at the apex, gradually tapering into the winged petiole, obtusely serrate-dentate at the margin; nerves, except for the midrib, very obscure. Scape short and stout, at most 5 mm. long, carrying from 2–4 rather large sessile flowers; bracts ligulate, 4–5 mm. long, obtuse at the apex, broad and somewhat sheathing at the base. Calyx green, cup-shaped, about 5 mm. long, divided to well below the middle into oblong or lanceolate obtuse ciliate lobes. Corolla probably of a purplish tint: tube 1 cm. long, narrowly cylindrical and in thrum-eyed flowers slightly ampliate above the middle; limb exannulate, up to 1·5 cm. in diameter; lobes patent, obovate and deeply emarginate, 5 mm. long and 4 mm. broad. The flowers are heteromorphic; in short-styled flowers the stamens are inserted in the middle of the corolla-tube and the style is little more than 1 mm. long.

The only specimens in the Edinburgh Herbarium are:

N.W. HIMALAYA. Kumaon (*Reid*, s.n.). (*Duthie*, 3137 is in the Kew and Calcutta Herbaria.)

P. Heydei Watt in Journ. Linn. Soc., xx, 5, t. 4c (1882); Hook. f. in Fl. Brit. Ind., iii, 487 (1882); Pax in Engler's Bot. Jahrb., x, 203 (1889), and in Engler's Pflanzenr. Primulaceae, 95, t. 28A (1905); Watt in Journ. Roy. Hort. Soc., xxix, 298, 302, 305 (1904), and in *ibid.*, xxxix, 199, 204, 205 (1913); Craib, *ibid.*, xxxix, 188 (1913); Smith et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 28 (1928), and in Journ. Roy. Hort. Soc., liv, 29, fig. 26 (1929).

P. Heydei, first collected by Thomson in the N.W. Himalaya at 4000–4700 m., is closely akin to *P. minutissima*. The distinction usually relied on is that in *P. Heydei* there is a definite scape with 2–8 flowers, while in its ally the scape is very short or absent and the flowers are mostly solitary. In the latter the flowers fit in closely with the mat of leaves. A comparison of the descriptions of the two as in Pax (*l.c.*) will yield no other valid marks. The colour is variously reported; Watt says originally "pale lilac," but in 1913 (*l.c.*) "beautiful blue"; *P. minutissima* has been given as bright purple, purple-blue and dark reddish-purple, but, according to Duby, the first discoverer, Jacquemont, made it rose. Hooker (*l.c.*) calls the plant a very distinct little species, but (*l.c.*, 494) suggests that the older species *P. minutissima* may be a reduced form of *P. Heydei*.

Not much stress can be put on the number of flowers in the scape for the two plants are often approximate in this respect. Moreover, in many Primulas an almost escapose inflorescence often develops a long scape at the fruiting stage. However, collections in herbaria favour separation but leave a doubt to be solved only by careful observations in the field.

P. Heydei was in cultivation for a short time in Edinburgh in 1919, raised from seed collected in 1916 by Cooper under No. 5433. The figure of this in Smith and Forrest (*l.c.*) would be just as applicable to *P. minutissima*. Cooper's herbarium specimen in fruit under the same number shows the scape of *P. Heydei*.

A dwarf, tufted, farinose plant, excluding the scape not much more than 1 cm. tall and producing leafy stolons up to 3 cm. long. Leaves lanceolate to oblanceolate, 7–10 mm. long, 3 mm. broad, acute at the apex, tapering into the petiole which is winged and about as long as the lamina, coarsely and distantly toothed at the margin, markedly creamy-farinose on the lower surface where the midrib and occasionally one or two pairs of the lateral nerves are quite conspicuous. Scape at first very short, later elongating to a height of 7 cm. though commonly shorter than that, stiff and erect, farinose especially towards the apex and bearing a capitulum of 2–8 flowers, surrounded by an involucre of bracts. Bracts unequal, lanceolate, up to 4 mm. long and 1 mm. broad, farinose, acute or obtuse at the apex and slightly pouched at the base. Calyx campanulate, farinose both within and without, 5 mm. long, cleft to below the middle into lanceolate acute lobes. Corolla-tube exannulate and about 8 mm. long, narrowly cylindric in pin-eyed flowers and ampliate from the middle in thrum-eyed, glabrous or only faintly farinose within; limb 10–12 mm. in diameter, with obcordate deeply emarginate lobes. Stamens in short-styled flowers inserted near the middle of the corolla-tube and a quarter of the way up the corolla-tube in long-styled. Style half as long as the corolla-tube in pin-eyed flowers and a quarter as long as the tube in thrum-eyed. Capsule included in the calyx and dehiscing by longitudinal valves.

The type is in the Kew Herbarium and in Edinburgh are the following:—

N.W. Himalaya. Kashmir, Baltistan (*Duthie*, 11972—in fruit); Lahul (*Drummond*, 8954); Chamba (*Lace*, 2047—in fruit); North of Lahul (*Cooper*, 5433); Rotang Pass, Kulu (C. 5545); Garhwal (*Smythe*, s.n.).

P. minutissima Jacquem. ex Duby in Mém. Soc. phys. d'hist. nat. Genève, x, t. 1, f. 3 (1843); Duby in DC. Prodr., viii, 42 (1844); Hook. f. in Fl. Brit. Ind., iii, 494 (1882) (excl. var.); Pax in Engler's Bot. Jahrb., x, 203 (1889), and in Engler's Pflanzenr. Primulaceae (excl. var. *spathulata*) 95, t. 28B (1905); Watt in Journ. Roy. Hort. Soc., xxix, 305. fig. 69*c* (1904), and in *ibid.*, xxxix, 205 (1913); Craib, *ibid.*, xxxix, 188 (1913); Smith et Forrest, *ibid.*, liv, 29 (1929), and in Notes Roy. Bot. Gard. Edin., xvi, 28 (1928). *P. Saundersiana* Royle mss. ex Hook. f., *l.c.* *P. Stracheyi* Hook. f. ex Munro in The Garden, xvi, 535 (1879)—pro parte.

The earliest collector of this species appears to be Royle in 1831, some years before Jacquemont. Specimens gathered by Royle in Kunawar are in the herbaria of Calcutta and Dehra Dun under a mss. name in Royle's handwriting—*P. minima*. Later on he designed to call it after his friend W. W. Saunders. The label in the Calcutta sheet carries also the statement: "Falconer took all my specimens"!!! Jacquemont's material was the basis for Duby's figure and description which leave no doubt as to the identity of the species. The question of its relationship to *P. Heydei* and *P. glandulifera* is referred to under these species. It remains to be proved whether *P. Heydei* is a scapose form of it. Authentic fruiting specimens of *P. minutissima* are rare in herbaria, but in one undoubted instance the scape is not elongate. Scapose fruiting material labelled *P. minutissima* in herbaria can equally be referred to *P. Heydei*. Collectors of *P. minutissima* in flower in the field should endeavour to find the quasi-persistent fruits of the previous season and should note whether the scape in these cases varies in elongation. According to Watt (*l.c.*, 205) the species was successfully grown in Europe, but nothing has been seen of it in culture since its recorded appearance at the Primula Conference of 1886.

A dwarf farinose plant growing at altitudes of 3500 5000 m.; the plantlets often occur in mat-like formations with the leaves and flowers scarcely projecting above ground level. There is a very short comparatively thick rhizome and the remains of numerous dead leaves are clustered around the base of the plant; sometimes short leafy stolons are thrown out. Leaves sessile or nearly so, at most 1 cm. long, 3 mm. broad, narrowly oblong or lanceolate or oblanceolate or sometimes almost spathulate, acute or acuminate, denticulate at the margin in the upper half, conspicuously yellow-farinose on the lower surface where the midrib is prominent and the other nerves obscure. Scape either obsolete or very short and then copiously covered with yellow farina, bearing 1-3 sessile flowers. At the base of the calyx there are 2-3 lanceolate bracts almost 3 mm. long, acute at the apex and sheathing at the base. Calyx tubular to tubular-campanulate, farinose both within and without, 3–4 mm. long, cleft to slightly below the middle into lanceolate acute lobes. Corolla dark reddish-purple with a yellow eye: tube exannulate, 2–3 times the calyx, narrowly cylindrical for the whole of its length in pin-eyed flowers and ampliate from the middle in thrum-eyed, glabrous or faintly puberulous within; limb up to 1 cm. in diameter with obovate, deeply emarginate, more or less patent lobes. Stamens inserted near the middle of the tube in thrum-eyed flowers and at the base in pin-eyed. Style two-thirds the length of the corolla-tube in long-styled flowers and shorter than the calyx in short-styled flowers. Capsule almost as long as the calyx, dehiscing by longitudinal valves.

The type is in the Paris Herbarium and in Edinburgh are the following:—

N.W. HIMALAYA. Sauch Pass (*Watt*, 760); Kashmir (*Duthie*, 11816); Garhwal (D. 711); Chamba (*Lace*, 2047—*in part*); Bashahr (L. 230); Simla Hill States (*Sherriff*, 7387).

P. muscoides Hook. f. ex Watt in Journ. Linn. Soc., xx, 15, t. 4D (1882) (excl. var.); Hook. f. in Fl. Brit. Ind., iii, 494 (1882) (excl. var.); Pax in Engler's Bot. Jahrb., x, 204 (1889), and in Engler's Pflanzenr. Primulaceae, 98 (1905); Smith in Rec. Bot. Surv. Ind., iv, 220, 393 (1911); Smith et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 28 (1928), and in Journ. Roy. Hort. Soc., liv, 29 (1929); Smith in Notes Roy. Bot. Gard. Edin., xix, 203 (1937).

P. muscoides was found by Hooker in the middle of last century during his exploration of Sikkim. It remained without description until 1882 when it appeared in Watt's paper and in the Flora of British India. It is now known to be not uncommon in alpine Sikkim and extends into Bhutan and S.E. Tibet. The original diagnosis pointed out that it is the smallest species of the genus, but some dwarf species occasionally approximate to it in the size of the vegetative parts. It is, however, readily distinguished by the tiny corolla with a tube not exceeding 5 mm. Other marks are the oblong to obovate sessile leaves with the serrations confined to the broad apex, the sessile flowers and the evolution of a short but distinct scape at the fruiting stage. The colour of the flower is violet or mauve, but white forms occur. There is no definite record of it in cultivation.

It is a very small densely tufted plant growing at altitudes of 4600–5300 m. in small clumps on open screes or among moss on open rocky hillsides. There is a very short rhizome and the base of the plant is girt by the withered remains of old leaves. The numerous leaves are efarinose, sessile, oblong to obovate, at most 10 mm. long, 5 mm. broad, coriaceous, with 3–7 acute lobes at the somewhat truncate apex; only the midrib is at all prominent, the other nerves being obscure. At flowering time there is no scape and the solitary flowers have a very short pedicel less than 1 mm. long, thickly coated with yellow farina; two small lanceolate unequal somewhat amplexicaul bracts are found at the base of the pedicel. Calyx cup-shaped and green, 2 mm. long, cleft to below the middle into triangular lobes, touched with yellow farina on the edges on the outside and thickly coated with farina on the inside. Corolla exannulate, about 7 mm. long, mauve with a yellow eye or pale violet with a white eye; tube whitish or completely white, at most 5 mm. long with the limb more or less in line; lobes narrowly oblong, deeply bifid; around the mouth numerous white hairs. The flowers are monomorphic; the stamens, with anthers nearly 1 mm. long, are inserted slightly below the middle of the corolla-tube and the stigma is level with the tips of the anthers. At fruiting time there is a remarkable scapose development, the fruit being carried 1 cm. or so above the level of the leaf-cushion. The nearly globose capsule, about 3 mm. in diameter, is more than half included in the calyx, the lobes of which are adpressed to it; it dehisces by 5 valves.

The following specimens in the Edinburgh Herbarium are representative:—

SIKKIM. Eumtso La (*Smith and Cave*, 1522); Chakung (*Smith*, 3863); Dobinda Pass (*Cooper*, 334, 896); On the Thanka La (C. 363).

S.E. TIBET. Seinghku Wang (*Ward*, 6986); Tsari (*Ludlow and Sherriff*, 2194, 2567); near Charme (*L. and S.*, 2311); near Paka (*L. and S.*, 5971); Chayne Chu (*L. and S.*, 2399).

BHUTAN. Changsethang (*Ludlow and Sherriff*, 3407).

P. praetermissa W. W. Sm. in Trans. Bot. Soc. Edin., xxxiii, 117 (1941).

In its general characters *P. praetermissa* is closely associated with *P. subularia*. It differs in the shape of the leaf, in the form of the calyx and in the much smaller corolla. Its discovery was somewhat fortuitous. Ludlow, Sherriff and Taylor made a gathering of *P. Genestieriana* Hand.-Mzt. during 1938 in S.E. Tibet under No. 5196. In this material were found intermixed the tiny plantlets of *P. praetermissa*. This is the only record of its occurrence. In the smallness of its parts it is a close rival to *P. muscoides* Hook. f.

A very dwarf plant up to 1·5 cm. tall, completely efarinose, clothed at the base by the withered remains of the old leaves. The numerous leaves, arranged in a rosette, are oblanceolate to spathulate, up to 10 mm. long including the petiole, 2 mm. broad, obtuse at the apex, markedly tapering into the winged petiole approximately the same length as the lamina, entire or occasionally distantly 1–3-toothed at the margin, sometimes with a few sessile glands on the lower surface: except for the prominent midrib, all the nerves are obscure on both surfaces. Scape very short, at most 3 mm. tall, carrying one terminal flower, with a single linear bract, 0·5 mm. long, inserted 1 mm. below the calyx. Calyx campanulate, up to 2 mm. long, lobed to the middle, the lobes being triangular and obtuse. Corolla bluish-purple and monomorphic with a cylindrical tube nearly three times as long as the calyx and a limb 5 mm. in diameter; lobes oblong, 2 mm. long, 1 mm. broad, conspicuously emarginate; mouth of the corolla loosely filled with white cottony hairs. Stamens, with anthers 0·5 mm. long, inserted just above the middle of the corolla-tube; style reaching the level of the stamens or slightly overtopping them. Ovary 1 mm. in diameter; nothing known of the capsule.

It is represented by one number only:

S.E. TIBET. *Ludlow, Sherriff and Taylor*, 5196A—*cotype*. (Type in Herb. Brit. Mus.)

P. reptans Hook. f. in Journ. Linn. Soc., xx, 14, t. 13B (1882); Hook. f. in Fl. Brit. Ind., iii, 494 (1882); Pax in Engler's Bot. Jahrb., x, 203 (1889), and in Engler's Pflanzenr. Primulaceae, iv, 96, t. 28C (1905). Coventry in Wild Flowers of Kashmir, Ser. I, 65, t. 32 (1923); Blatter in Beautiful Flowers of Kashmir, II, 20, pl. 38, fig. 4 (1928); Smith et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 28 (1928), and in Journ. Roy. Hort. Soc., liv, 29 (1929). *P. Stracheyi* Hook. f. ex Munro in The Garden, xvi, 535 (1879)—pro parte.

Long before it received description as a species, this very dwarf West Himalayan plant was found by various collectors—Falconer, Strachey and Winterbottom, and Stewart—and in the 'seventies by Ellis, Clarke and Tanner. Some of these collections in certain Herbaria still show the mss. name, *P. Stracheyi*, but that name was affixed also to specimens of *P. minutissima*. In one collection both species intermingled appear under that name.

P. reptans is well distinguished by the stoloniferous habit, by the very small leaves which are as broad as long, with characteristic teeth, and by the proportionately large flower equal in size to the rest of the plant. *P. muscoides* has very small leaves, but its flower is also tiny. The leaf-characters and the lack of farina mark off *P. reptans* from both *P. minutissima* and *P. Heydei*. The species has been in cultivation during recent years but has a precarious foothold.

A dwarf markedly stoloniferous plant forming compact cushions among moss on open hillsides at altitudes of 4000–5000 m. For the size of the plant the underground stems are stout, horizontal, rooting below and clothed above with the remains of old leaves. Leaves spoon-shaped, efarinose, at most 1 cm. long, with the winged petiole longer than the lamina which is up to 4 mm. across, as broad as long, rounded at the apex, cuneate at the base and deeply incised-lobed at the margin, the lobules being obtuse and usually recurved, and with all the nerves except the midrib very obscure. Scape almost obsolete or up to 3 mm. long, slightly farinose, carrying a solitary flower; bracts 2 or 3, unequal, lanceolate, obtuse, faintly farinose, the largest one up to 3·5 mm. long; pedicel 2–3 mm. long, slightly farinose. Calyx green, cup-shaped, 3 mm. long, slightly farinose on the outside, quite copiously farinose on the inside, cleft to the middle or to slightly below the middle into lanceolate acute finely ciliate lobes. Corolla exannulate, violet with a white eye and the tube, especially the inside, reddish; tube narrow and cylindrical, usually about three times as long as the calyx, often slightly farinose without, hairy within at the throat and some distance down the tube; limb 1–1·5 cm. in diameter, the lobes being obovate, conspicuously emarginate and puberulous at the base. Stamens inserted near the middle of the corolla-tube in thrum-eyed flowers and slightly above the ovary in pin-eyed flowers. Style half as long as the corolla-tube in long-styled flowers and barely 1 mm. long in short-styled flowers.

It is adequately represented in the Edinburgh Herbarium by the following:—

N.W. Himalaya. *Stewart*, s.n.; Hazara (*Inayat*, 19917); Kumaon (*Duthie*, 24651); Kashmir (*Duthie*, 13236); Kulu (*Cooper*, 5098, 5109); Barai Valley (*Ludlow and Sherriff*, 1477); Simla Hill States (*Sherriff*, 7407, 7512). The type is in Herb. Kew.

P. rhodochroa W. W. Sm. in Notes Roy. Bot. Gard. Edin., xv, 75 (1926); Smith et Forrest, *ibid.*, xvi, 28 (1928), and in Journ. Roy. Hort. Soc., liv, 29 (1929); Smith in Notes Roy. Bot. Gard. Edin., xix, 204 (1937).

Among the definitely farinose Minutissimae, *P. rhodochroa* and *P. Geraldinae* are readily recognised by the short corolla-tube which equals or slightly exceeds the calyx. Both have been found only in S.E. Tibet, a little beyond the Indian Himalaya. *P. rhodochroa* in its typical form is only 3 cm. or even less in height, with oblanceolate leaves regularly and deeply serrate and with a solitary flower as large as the rest of the plant. It varies much, however, probably in accordance with the habitat. The greatest divergence is shown in the flower which may be only one-third the size of that in the typical plant, while the characters of foliage and scape remain the same. In other cases the scape develops more strongly, is 1–4-flowered, and the leaves lengthen to linear-oblanceolate with their margins more patent-dentate than serrate. On the whole, the evidence is in favour of regarding all these plants as conspecific; intermediate conditions occur; in the same individual collections a considerable range in the size of the corolla and in leaf-form is observable; in the opinion of the collectors in the field the aberrations were varietal rather than indicative of specific value. The nearest ally is *P. Geraldinae* with more obscurely serrate, fleshier leaves, with yellow farina and larger flowers. Neither has been recorded in cultivation.

A dwarf farinose plant, at most 3 cm. tall, growing on mossy cliff ledges and on open grassy steep slopes at altitudes of 4000–5000 m. There is a short stout rhizome and the base of the plant is covered with the withered remains of old leaves. Leaves forming a dense tuft, oblanceolate to narrowly obovate, 5–20 mm. long, 3–5 mm. broad, obtuse or rounded at the apex, quickly tapering into the winged petiole which when fully developed is as long as the lamina, conspicuously dentate, green above with a very thin covering of potentially farinose glands, thickly covered below with white farina; midrib and 4–5 pairs of lateral nerves quite conspicuous on the lower surface. Scape at most 1 cm. long but usually much shorter and immersed in the leaves, markedly farinose, carrying 1–4 flowers; bracts 2–3, linear, farinose, 4–5 mm. long; pedicels farinose, up to 8 mm. long. Calyx narrowly cup-shaped, at most

7 mm. long, farinose both within and without, rather sparsely so within, very prominently 5-veined and lobed for slightly more than a third of its length, the lobes being triangular to ovate, and acute or obtuse. Corolla purplish-pink with an orange-yellow eye or occasionally white with a lemon-green eye, faintly powdered with farina on the outside and quite conspicuously farinose within: tube annulate, as long as the calyx; limb up to 1·5 cm. in diameter (but often much less), with obcordate, deeply emarginate lobes 6 mm. long and 4 mm. broad. Stamens in pin-eyed flowers inserted slightly below the middle of the corolla-tube and slightly below the annulus in thrum-eyed flowers. Long style reaching the annulus, short style about half as long as the corolla-tube. Capsule more or less as long as the calyx and dehiscing by longitudinal valves.

The type is in the British Museum and the species is represented in Edinburgh by:

S.E. TIBET. On the Doshong La (*Ward*, 5835—*cotype*); on the Num La (W. 6050); Seinghku Wang (W. 7018, 7053); Tsari (*Ludlow and Sherriff*, 2137*, 2177*, 2539); on the Kashong La (*L. and S.*, 2371); Paka Phu Chu (*L., S. and Taylor*, 5890); near Paka (*L., S. and T.*, 6504); Langong (*L., S. and T.*, 3918*); *L., S. and T.*, 4736, 5218*, s.n.

The collections with an asterisk are those with very small flowers and are marked in the herbarium as var. *microstoma*.

P. rimicola W. W. Sm. in Trans. Bot. Soc. Edin., xxxiii, 118 (1941).

Nothing is known of this rare species apart from the one collection made in 1936 by Ludlow and Sherriff in S. Tibet. It grows in sheltered crevices in cliffs on the Kashong La at an elevation of 5000 m. By mid-July the flowers are mostly over. In its foliage characters, but not in its flower, it bears a general resemblance to *P. Clutterbuckii* of the section Farinosae. In its flower, affinity is indicated with *P. tenella*, but there are differences in the bracts, in the calyx, and in the lack of hairs within the corolla-tube.

A dwarf tufted plant, up to 3 cm. tall excluding the flower, with a short stout rhizome and covered at the base by the withered remains of old leaves. Leaves thin in texture and numerous, forming a compact rosette, oblanceolate to spathulate, at most 3 cm. long including the petiole, with the lamina 7 mm. broad, rounded at the apex, tapering into the membranously winged petiole, denticulate and rather irregularly so at the margin, often with a little farina above and thickly plastered with yellow farina below where midrib and 5–6 pairs of lateral nerves are prominent. The flowers are solitary; scape at first very short, almost completely concealed by the leaves, later elongating to 2–2·5 cm., covered with yellow farina; bracts 2–3, lanceolate to linear-lanceolate, 2–5 mm. long, farinose; pedicels 2–3 mm. long. Calyx green, membranous, cup-shaped, 6–7 mm. long, sprinkled with farina on the outside and copiously farinose on the inside, cleft for three parts of its length into lanceolate acute lobes fringed with farina-secreting hairs. Corolla exannulate, slightly purplish-pink with a white to yellow eye and sparsely farinose on the outside; tube cylindrical, slightly ampliate towards the apex, twice as long as the calyx, glabrous on both sides or with a few microscopic white hairs inside; limb 1·5 cm. in diameter, with patent obcordate deeply emarginate lobes 7 mm. long and broad. Stamens situated towards the base of the corolla-tube in pin-eyed flowers and the style slightly longer than the calyx. Capsule (imperfect) barely as long as the calyx.

It is represented by:

S. TIBET. Kashong La (*Ludlow and Sherriff*, 2359—*cotype*). Type in Herb. Brit. Mus.

P. spathulifolia Craib in Journ. Roy. Hort. Soc., xxxix, 190 (1913); Smith et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 28 (1928), and in Journ. Roy. Hort. Soc., liv, 29 (1929). *P. minutissima* Jacquem. var. *spathulata* Hook. f. in Fl. Brit. Ind., iii, 494 (1882); Pax in Engler's Pflanzenr. Primulaceae, 96 (1905). ? *P. melichlora* Balf. f. et W. W. Sm. in Notes Roy. Bot. Gard. Edin., ix, 29 (1915–16).

P. spathulifolia was first found by Hooker in Sikkim during his Himalayan explorations. No definite locality was stated and the elevation was given as 4300 m. The original specimens were scanty and remained unnamed until 1882 when Hooker (*l.c.*) attached them to *P. minutissima* under the varietal name *spathulata*. At the time no other specimens were available and during the intervening sixty years the plant has rarely been refound. This is somewhat surprising as Sikkim, to which the species appears to be confined, has been almost annually explored for plants and seeds. As far as the evidence goes *P. spathulifolia* is a native of Eastern Sikkim, in the neighbourhood of the Lachung Valley, an area less often visited by the seed-collectors of the Lloyd Botanic Garden.

Only two additional records are known. Pantling collected it in flower at Namdee opposite Lachung at 3300 m. in little masses on exposed faces of rock in May 1885, and states that it is purple with a yellow or white eye. The second record is by Mrs. Townend who found it in flower in May 1936 in the valley above Sibu-Chu, N.E. of Lachung at 4700-5000 m. In Watt's herbarium there is a small specimen, probably received from Hooker and not collected by Watt; this bears a note expressing the latter's opinion that the plant is a perfectly good new species and is near *P. Stirtoniana*. This can be admitted even though the last-named is efarinose and with different foliage. The link with *P. minutissima* and *P. tenella* is more remote.

P. melichlora must be considered here. It is referred to in Rec. Bot. Surv. Ind., iv, 393 (1913), under *P. minutissima* var. *spathulata*. The material on which the description is based (*Smith*, 4071 in Herb. Calc.) was collected at Tosa in Eastern Sikkim in August and thus too late for flowers. The leaves are not exactly matched in what is available of *P. spathulifolia* and are more deeply serrate. The probability is in favour of the view taken here that *P. melichlora* represents a later stage of *P. spathulifolia*. Only further collections in the Lachung area in Eastern Sikkim can settle the question.

P. spathulifolia is a small tufted farinose plant, at most 4 cm. tall with a short relatively thick rhizome. Leaves spathulate, up to 2·5 cm. long including the petiole which equals the lamina and is broadly winged; lamina about 7 mm. broad, rounded or obtuse at the apex, quickly tapering into the petiole, entire or finely serrulate in the upper half, often densely farinose on both surfaces but especially below; midrib prominent and nerves obscure. Scape absent. Pedicel up to 10 mm. long, markedly farinose with two unequal, farinose, narrowly lanceolate or ligulate acute bracts at the base, up to 5 mm. long. Calyx green, campanulate, 5–7 mm. long, farinose both within and without, cleft at least to the middle into ovate to elliptic to lanceolate lobes acute or obtuse at the apex. Corolla purple with a white or yellow eye; tube slightly farinose without, exannulate, more or less glabrous within, cylindrical and about twice the length of the calyx; limb up to 2 cm. in diameter with the lobes patent, obovate, 7·5 mm. long, 5–6 mm. broad, and deeply emarginate. Stamens in thrum-eyed flowers inserted slightly above the middle of the corolla-tube and towards the base of the corolla-tube in pin-eyed flowers. Style in long-styled flowers a little more than half the length of the calyx and barely 1 mm. long in short-styled flowers. Capsule not known.

The type is in the Kew Herbarium. In Edinburgh are the following:—

Sikkim. Namdee (*Pantling*, s.n.); N.E. of Lachung (*Townend*, 36); Tosa (*Smith*, 4071—*cotype* of *P. melichlora*).

P. Stirtoniana Watt in Journ. Linn. Soc., xx, 15, t. 15D (1882); Hook. f. in Fl. Brit. Ind., iii, 495 (1882); Pax in Engler's Bot. Jahrb., x, 204 (1889), and in Engler's Pflanzenr. Primulaceae, 98 (1905); Ostenfeld in Sven Hedin's Southern Tibet, 50 (1922); Watt in Journ. Roy. Hort. Soc., xxix, 300, 320, fig. 73B (1904), and in *ibid.*, xxxix, 202, 215 (1913); Smith et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 28 (1928), and in Journ. Roy. Hort. Soc., liv, 29 (1929).

This rare species was collected by Watt in 1881 on the Surkia La, near Kanglanama La, on the northern frontier of Sikkim at an elevation of 4700 m. Since that date it appears to have been found again only on three occasions in the Himalaya. King's collector secured it in 1887 on the Pey-kiong-la near Jongri and in 1889 on the Nyegu La near the Nepal frontier. In 1937 Ludlow and Sherriff obtained it in Central Bhutan. Ostenfeld recorded it with some reservation as collected by Sven Hedin in S.W. Tibet near the source of the Tsangpo, but his material is not meanwhile available here for inspection. The species is associated with other East Himalayan plants such as *P. tenuiloba* and *P. Waddellii* from which it is readily distinguished by the broad obcordate lobes of the corolla. In general habit it resembles *P. rimicola* which is, however, markedly yellow-farinose. It has not been in cultivation.

A small tufted efarinose plant up to 4 cm. tall, growing at altitudes of 4600–5300 m. among moss on cliff faces, with a short rhizome, girt at the base by the brown withered remains of last year's leaves. The more or less spathulate leaves are up to 2 cm. long, 5 7 mm. broad; petiole narrowly winged, longer or shorter than the lamina blade, particularly the upper two-thirds, strongly incised-dentate, about twice as long as broad; both sides of the leaf are finely scabrid and apart from the prominent midrib, the nerves are obscure. Scape minute, at most 2 mm. long, so that the solitary flowers are immersed in the foliage, the calyx being quite concealed; usually two unequal linear-ligulate bracts. Calyx green, campanulate, scabrid, 6–7 mm. long, cleft to slightly below the middle into ovate-lanceolate lobes usually prominently toothed towards the apex. Corolla exannulate, pale bluish-violet or lavender-blue, with a white eye; outside of lobes paler; corolla-tube almost white outside and very slightly yellow within, narrow and cylindrical, slightly ampliate towards the apex, about 1 cm. long; limb about 1·5 cm. in diameter, with more or less patent obovate deeply emarginate lobes about 5 mm. long; at the mouth of the corolla a few white hairs. Stamens, with anthers 1 mm. long, inserted two-thirds up the corolla-tube in thrum-eyed flowers and one-third up the tube in pin-eyed. Style two-thirds as long as the corolla-tube in long-styled flowers and one-third as long in short-styled; ovary 1 mm. in diameter. Capsule not seen.

In the Edinburgh Herbarium is the following representation:—

SIKKIM. Surkia La (*Watt*, 5419—*type*).
BHUTAN. Dungshinggang (*Ludlow and Sherriff*, 3258).

P. subularia W. W. Sm. in Notes Roy. Bot. Gard. Edin., xix, 204 (1937).

This tiny Primula has but a brief history. It was found in S.E. Tibet in 1936 by Ludlow and Sherriff at elevations of 4500–4800 m., and on two occasions in 1938 in the same region by Ludlow, Sherriff and Taylor. It forms a mat-like growth on wet rocks, often intermixed with mosses, hepatics and a dwarf Polygonum. In its section it is at once distinguished by the linear entire leaves. Its nearest ally is *P. praetermissa*. It does not show any relationship with any member of the Farinosae. There is no record of its cultivation.

A dwarf efarinose plant, about 2 cm. tall, with a very short rhizome and with the base covered by the remains of old leaves. The leaves in a compact rosette are subulate, up to 10 mm. long, 1 mm. broad, acute at the apex, hardly any narrower at the base than in the middle; petiole almost obsolete; veins quite obscure and midrib far from prominent. Flowers solitary and erect, with very short pedicels, at most 3 mm. long, completely hidden by the leaves. Calyx green, narrowly cup-shaped, about 3 mm. long, divided to the middle or slightly below into oblong lobes rounded or obtuse at the apex where there is a single hydathode. Corolla exannulate, monomorphic, rose-purple, 10–13 mm. long, about 8 mm. broad across the limb, minutely puberulous outside; tube narrowly cylindrical though slightly ampliate in the upper part, about 8 mm. long, thinly covered within with cottony hairs; lobes semi-patent, narrowly obcordate, about 4 mm. long, deeply emarginate. Stamens, with anthers 0·5 mm. long, inserted 2 mm. above the base of the corolla-tube; style 2 mm. long.

The type is in the British Museum and the species is thus represented in the Edinburgh Herbarium:—

S.E. TIBET. On the Lo La (*Ludlow and Sherriff*, 1912—*cotype*, *Ludlow, Sherriff and Taylor*, 6553); Langong (*Ludlow, Sherriff and Taylor*, 5561).

P. tenella King ex Hook. f. in Fl. Brit. Ind., iii, 492 (1882); Watt in Journ. Linn. Soc., xx, 13, t. 12B (1882); Pax in Engler's Pflanzenr. Primulaceae, 97 (1905); Craib in Journ. Roy. Hort. Soc., xxxix, 188 (1913); Watt in *ibid.*, xxxix, 201, 203, 208, 210 (1913); Smith et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 34 (1928), and in Journ. Roy. Hort. Soc., liv, 38, fig. 29 (1929); Stapf in Bot. Mag., t. 8881B (1938).

P. tenella was first collected in 1878 and again in 1879 in the Chumbi Valley, S. Tibet, by Dungboo, Sir George King's collector. King recognised it as a new species and on the type (*Dungboo*, anno 1878, in Herb. Calc.) has himself written the name giving the locality as Goop, 13 miles from Phari. For many years the only additional collections came from Chumbi or the immediate vicinity, but more recently *P. tenella* has been obtained by Cooper, Ludlow and Sherriff, and Gould in Bhutan. It has not been seen in Sikkim.

Its sectional allocation is not outwith dispute. King placed it near *P. uniflora* and *P. soldanelloides* but with tube of flower long (King mss. on type sheet). In the Flora of British India (*l.c.*) it accompanies three Sikkim species certainly not related to it. Pax (*l.c.*) made it the leading species of his section Tenellae and among its kin he quoted *P. bella*, *P. muscoides*, and *P. tenuiloba*. This is certainly near the mark. Smith and Forrest (*l.c.*) recorded it in Balfour's section Obtusifolia. But *P. obtusifolia*, the leading species of that section, is now known to be a Nivalid and the section itself disintegrates chiefly to Farinosae and Nivales. Stapf (*l.c.*) considers that *P. tenella* comes very near to *P. bella*. The small section Bella was distinguished by the strong development of a pompon of hairs on the annulus completely occluding the orifice. Stapf regards this special villosity in *P. bella* as only a matter of degree and no bar to the association of *P. tenella* with *P. bella*. Acceptance of this view entails the inclusion of section Bella in Minutissimae, to which there is no fundamental objection. *P. tenella* finds its nearest ally in *P. flagellaris*, while *P. tenuiloba* and *P. Stirtoniana* are in less close relation. *P. flagellaris* has a smaller but similar flower, an ebracteate scape and very long thread-like stolons. *P. tenella* has almost invariably a single linear bract just below the calyx, very rarely two. As noted in the field by Ludlow and Sherriff, *P. flagellaris* begins formation of the stolons in early August as the fruits ripen. There is no similar development in late collections of *P. tenella*, though it may occasionally produce very short leafy stolons from the old stock. The two are, however, so closely linked in general aspect that further observations, particularly in the Chumbi Valley, are desirable.

P. tenella is a small tufted plant with a short rhizome, girt at the base with the withered remains of the leaves of the preceding year, and occasionally developing short leafy stolons from the old stock; it is reported to grow at elevations of 4700–5000 m. nearly always on cliff faces or in cracks in rocks, generally in masses, less often singly or a few together. Leaves numerous, white-mealy below and sometimes sparingly so above; lamina 6–15 mm. long, 5–8 mm. broad, variable in shape from rhomboid to obovate and spathulate, more or less rounded at the apex, with a long cuneate base, dentate or crenulate generally in the upper half only: petiole sometimes short, generally as long as the blade, or even 2–3 times longer. Scape mealy, erect, 2–5 cm. long, with a single flower, very rarely two; one linear or subulate bract placed usually immediately below the calyx but sometimes a little lower down; pedicel consequently very short. Calyx 4–8 mm. long, tubular-campanulate, cleft to the middle or slightly beyond, more or less mealy; lobes sublinear, obtuse or pointed. Corolla funnel-shaped, with a flat limb up to 2·5 cm. across, usually a rich blue-violet but sometimes with a shade of red; the large eye is white; lobes obcordate, deeply cleft; tube 1–1·4 cm. long, slenderly cylindrical below, expanded above, sprinkled with meal as is the limb, finely hairy inside from the annulus down to the insertion of the stamens. Anthers about 2 mm. long, inserted just above the middle of the tube or in pin-eyed flowers about 3 mm. from the base. The shorter style about 3 mm. long; the longer style reaches the mouth of the corolla-tube. Capsule very small (only one apparently mature example seen), subglobose like the ovary and enclosed within the calyx-tube.

The species is represented in Edinburgh by the following:—

S. TIBET. Chumbi Valley (*Dungboo*, in Herb. Watt—*cotype*); (*Dungboo*, anno 1879); (*Ribu*, 7700); (*Ribu and Rhomoo*, 170).

BHUTAN. Lingshi Timpu (*Cooper*, 1660); Tang Chu (*Ludlow and Sherriff*, 3249); on the Tremo La (*Gould*, 1159).

P. tenuiloba (Hook. f.) Pax in Engler's Bot. Jahrb., x, 204 (1889); Pax in Engler's Pflanzenr. Primulaceae, 98 (1905); Smith in

Rec. Bot. Surv. Ind., iv, 220 (1911), and in *ibid.*, iv, 393 (1913); Craib in Journ. Roy. Hort. Soc., xxxix, 188 (1913); Smith et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 28 (1928), and in Journ. Roy. Hort. Soc., lxiv, 29 (1929); Smith in Notes Roy. Bot. Gard. Edin., xix, 204 (1937). *P. muscoides* Hook. f. var. *tenuiloba* Hook. f. in Journ. Linn. Soc., xx, 15, t. 13A (1882), and in Fl. Brit. Ind., iii, 495 (1882). *P. indobella* Balf. f. et W. W. Sm. in Notes Roy. Bot. Gard. Edin., ix, 24 (1915).

P. tenuiloba was discovered by Hooker during his classic exploration of the Sikkim Himalaya. The material collected was scanty and remained unidentified until Watt in an extensive mss. paper recognised it as a distinct species. In his revision of this paper Hooker, in view of the inadequate specimens, accorded the plant varietal rank only, though he thought it might prove to be distinct. Pax (*l.c.*, 98) gave it specific rank, although Hooker's material under No. 22 was apparently not seen by him. Since that time the species has been frequently collected, not only in Sikkim, but also in Nepal, Bhutan, and the adjoining parts of South and S.E. Tibet. It can be readily recognised among the Minutissimae by the efarinose leaves, deeply serrate for the size of the lamina, by the presence of long white hairs on the outside of the corolla as well as frequently but not invariably on the scape and calyx, by the very narrow lobes and lobules of the corolla-limb, and by the scattered hairs in the corolla-throat and inside the tube. Of its associates in the same area *P. muscoides*, *P. Stirtoniana*, and *P. Waddellii*, the nearest in general character is *P. Waddellii*. The very small corolla of *P. muscoides* is one of several reasons for precluding it from near kinship with *P. tenuiloba*.

A dwarf tufted efarinose plant growing to a height of up to 2 cm. (not including the flower) and inhabiting open rocky hillsides and moss-covered boulders at 4600–5400 m. altitude. There is a very short rhizome and the withered remains of old leaves cover the base of the plant. Leaves up to 2 cm. long, spathulate, with the broad winged petiole longer than the lamina which is at most 4 mm. across, obtuse or rounded at the apex, tapering at the base, very deeply serrate at the margin and with the midrib alone prominent on the lower surface, the rest of the nerves being obscure. Scape up to 2 cm. tall, often much shorter, carrying a solitary sessile flower and usually with a thin covering of small white hairs; bract solitary, arising immediately at the base of the calyx, linear, up to 4 mm. long, very slightly pouched at the base. Calyx green, campanulate, up to 5 mm. long, sometimes hairy on the outside, divided to the middle into ovate to oblong to elliptic lobes, often tinted with purple, conspicuously veined and strongly toothed at the apex. Corolla exannulate, bright bluish-violet with a white eye, or occasionally white; tube at most twice as long as the calyx, in pin-eyed flowers gradually ampliate from the base, in thrum-eyed flowers ampliate above the insertion of the stamens, covered with long white cottony hairs both within and without, especially within; limb 1·5 2 cm. in diameter, with narrowly obcordate very deeply emarginate lobes, the lobules being conspicuously narrow. Stamens, with anthers 1 mm. long, inserted near the middle of the corolla-tube in short-styled flowers and at the very base of the tube, surrounding the ovary, in long-styled flowers. Style half as long as the corolla-tube in long-styled flowers and 1 mm. long in short-styled flowers. Capsule shorter than the calyx and dehiscing by longitudinal valves.

The type is in the Kew Herbarium and in Edinburgh the following are representative:—

SIKKIM. *Cooper*, 726.

NEPAL. *Sharma*, E.93, E.349 (a white var.), E.393.

BHUTAN. On the Me La (*Ludlow and Sherriff*, 395); Changsethang (*L. and S.*, 3417); Champa Punthang (*Cooper*, 4038); Narim Thang (C. 4269).

S. and S.E. TIBET. On the Kachen La (*Ludlow and Sherriff*, 674); on the Drolma La, Tsari (*L. and S.*, 2172); on the Kashong La, Chayne Chu (*L. and S.*, 2354).

P. Waddellii Balf. f. et W. W. Sm. in Notes Roy. Bot. Gard. Edin., ix, 56 (1915–16); Smith et Forrest in *ibid.*, xvi, 28 (1928), and in Journ. Roy. Hort. Soc., liv, 29 (1929).

This little-known plant was described from two scanty collections in the Calcutta Herbarium, secured in S. Tibet in 1891 by Major L. A. Waddell, I.M.S., who travelled widely in the Himalaya and was an authority on matters Tibetan. The specimens had previously been referred to *P. Stirtoniana*. The material, as will be seen from the first diagnosis, did not rule out intimate connection with that species. The collections made, however, in later years in Bhutan by Cooper and by Ludlow and Sherriff have served to make clear the position. It is quite distinct from *P. Stirtoniana* in its leaf-shape and serration and particularly in the form of the corolla. A much nearer ally is *P. tenuiloba* to which it bears a marked resemblance. It differs in the shape and serration of the lamina and in the corolla being quite glabrous outside. As in its ally, the corolla-tube is somewhat hairy inside and not glabrous as in *P. Stirtoniana*. In both *P. Waddellii* and *P. tenuiloba* farini-potent glands may be present on leaf and inflorescence, and occasionally farina can be observed under the lens but it is never obvious to the naked eye and both species were described as efarinose. *P. Waddelii* has never been in cultivation.

A dwarf caespitose plant, excluding the flower not much more than 1 cm. tall, growing at altitudes of 4000–5000 m. in peaty turf and in the cracks of rocks. Usually it is completely efarinose, though often there may be a covering of farini-potent glands on the leaves and inflorescence. There is a short rhizome and the withered remains of old leaves clothe the base of the plant. Leaves quite thick, spathulate, about 1 cm. long and up to 5 mm. broad, rounded at the apex, tapering into the winged petiole, conspicuously crenulate to denticulate at the apex or upper half; apart from the midrib nerves very obscure. Flowers solitary and sessile on a short puberulous scape at most 3 mm. long, though usually much shorter and with a minute subulate bract pressed close to the calyx. Calyx cup-shaped, 5 mm. long, split to the middle or to slightly below into lanceolate to oblong-lanceolate acute lobes. Corolla purplish-blue or almost pink with a touch of blue and with a white eye; tube exannulate, about 1 cm. long, narrowly cylindrical, on the inside with white cottony hairs extending down the tube; limb 1·2 cm. in diameter with narrowly obovate and very deeply bifid lobes sometimes patent and at other times more in line with the corolla-tube. Style in long-styled flowers at least half as long as the corolla-tube; stamens inserted almost at the base, so that they form a conical covering to the ovary; in thrum-eyed flowers stamens inserted near the middle of the corolla-tube; style hardly 1 mm. long. Nothing is known of the capsule.

The following sheets in Herb. Edinburgh are representative:—

BHUTAN. On the Tremo La (*Cooper*, 3835); Champa Punthang (C. 4039). Dungshinggang (*Ludlow and Sherriff*, 3281).

P. Walshii Craib in Journ. Roy. Hort. Soc., xxxix, 187, 190 (1913); Smith et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 25 (1928), and in Journ. Roy. Hort. Soc., liv, 33 (1929). *P. petrocharis* Pax et K. Hoffm. in Fedde Repert. Nov. Spec., xvii, 95 (1920–1921); Smith in Notes Roy. Bot. Gard. Edin., xix, 203 (1937).

The first collecting of this species was made in 1904 by E. H. Walsh when on the Tibet Frontier Commission. It was found in flower at the end of May in the Chumbi Valley on the way to Phari and therefore in Tibet and outside Sikkim territory. The type, *Walsh*, 141, is in the Kew Herbarium: the cotype in Calcutta is a mixture of the species with *P. pumilio*. Evidently they grew in proximity and Craib in his diagnosis places the new species as closely akin to the plant of Maximowicz and in the section Farinosae. There is certainly a general resemblance but their relationship is more doubtful. In a note accompanying the herbarium sheets Balfour expresses the view that *P. pumilio* finds its nearest allies among the auriculate species, while *P. Walshii* tends to Minutissimae. Likewise in the description by Pax of the synonymous *P. petrocharis* the same section is indicated. Apart from the dwarf habit and comparatively short corolla-tube, the most ready mark for recognition of *P. Walshii* is the peculiar calyx which is coarsely scabrid-pubescent. Nothing quite like it is to be found throughout the Farinosae nor indeed in the Minutissimae. In any case the distinction between these two sections is difficult to draw. Material of *Limpricht*, 1329 and 1470, representing *P. petrocharis* has been examined and these Szechwan plants agree with Chumbi and Bhutan specimens of *P. Walshii*.

The species was in cultivation for a brief period and flowered in August 1936 at Edinburgh. The plants were raised from seed collected by Dr. Harry Smith of Upsala under No. 12280 in the province of Sikang, N.W. China.

A dwarf efarinose glandular-pubescent plant, growing at an altitude of from 4000–5000 m. on steep, alpine, grassy slopes. There is a short comparatively stout rhizome and the base of the plant is clothed by the withered remains of numerous old leaves. Leaves including the petioles 8–15 mm. long, 3–5 mm. broad, oblanceolate to oblong-lanceolate, acute or obtuse at the apex, cuneate at the base, covered on both surfaces with numerous short glandular hairs which give the leaves a markedly scabrid appearance, and with only the midrib at all conspicuous; petiole winged, usually 2–3 mm. long. At flowering time scape very short, immersed in the leaves, carrying 1–4 flowers; bracts about 2 mm. long, ovate to lanceolate, attenuate at the apex, broadly clasping at the base, forming a small cup-shaped involucre from which arise the flower pedicels, more or less as long as the bracts, like them glandular-puberulous. Calyx tubular to tubular-campanulate, 4–5 mm. long, coarsely glandular-pubescent, divided to a third or a half into ovate to lanceolate segments, acute or obtuse and often slightly incurved at the apex. Corolla bright red-pink when first open, gradually fading to pink, with the eye usually yellow though sometimes white; tube exannulate, 1–1¼ times as long as the calyx, glabrous within; limb at most 8 mm. in diameter, with broadly obovate very deeply emarginate lobes. Stamens in pin-eyed flowers inserted near the middle of the corolla-tube and the style at least two-thirds as long as the tube; in thrum-eyed flowers the stamens are inserted in the upper half of the corolla-tube and the style is half as long as the tube. In fruit the scape is as much as 3 cm. long and the oblong capsule, slightly longer than the calyx, dehisces by longitudinal valves.

The species is represented at Edinburgh by the following:—

Bhutan. Lingshi Timpu (*Cooper*, 1658); on the Tremo La (C. 3836); Rong-chu (*Ward*, 5802); Luguthang (W. 11637); Charme (W. 11827).

S.E. Tibet. Tsari (*Ludlow and Sherriff*, 1599, 2044); Sanga Chöling (*L. and S.*, 2256); on the Kongbo Nga La (*L., S. and Taylor*, 3604); Nyang Chu (*L., S. and T.*, 6186). *L., S. and T.*, 4067, 4235, 5425 without locality.

N.W. China. Sikang (*Harry Smith*, 12280).

Subsection II (Bella).

A. Leaves distinctly scabrid with glands or short hairs; efarinose or nearly so:
  B. Leaves spathulate or oblanceolate, subpinnatifid; corolla-tube slightly exceeding calyx (E. Himalaya and Tibet) . . *pusilla*
  BB. Leaves suborbicular or fan-shaped; serrate in upper half; corolla-tube twice the calyx (S.E. Tibet) . . . . . . *occlusa*
AA. Leaves not scabrid; farinose or efarinose:
  B. Efarinose; corolla-throat with dark purple pompon (S.E. Tibet) *barbatula*
  BB. Farinose or not; pompon of hairs white (S.W. China and Burma):
    C. Farina yellow or absent; stolons very short or 0 *bella* and subspp.
    CC. Farina white; flagellate stolons . . . . *moschophora*

P. barbatula W. W. Sm. in Notes Roy. Bot. Gard. Edin., xiv, 201 (1937).

This very neat and quite distinct little species was found in 1936 by Ludlow and Sherriff on the Kashong La, S.E. Tibet, at an elevation of 5000 m. It has since been collected in 1938 on two other passes in the same region at a somewhat lower elevation. Its nearest allies are *P. bella* and *P. pusilla*. From these it is distinguished by the smaller habit, by the efarinose glabrous leaves, by the much smaller flowers and by the pompon of hairs in the throat of the corolla being a deep purple or dark violet and not white. It has not been in cultivation.

The plant, including the flower, measures 2-2·5 cm. in height. It is recorded by the collectors as growing either singly or in mossy clumps on open stony hillsides and on cliff ledges. The slender rhizome is covered above with the withered leaves of the previous season and short stolons (3-5 mm.) are often produced. Leaves including the petiole 4-8 mm. long, 1–4 mm. broad, spathulate, without hairs and without farina, rounded in outline at the apex but with 3-7 large teeth in the upper half of the lamina; texture somewhat fleshy and nervation obscure; petiole usually 2–3 times longer than the lamina, narrowly winged. Flower solitary, more or less equal to the rest of the plant in size; scape 4–15 mm. in height, with a single linear bract a little below the calyx; pedicel 1-2 mm. long. Calyx cupular, about 2 mm. long, glabrous, without farina, divided to the middle into narrowly triangular subacute erect lobes. Corolla pinkish-purple to mauve or blue-violet, about 6 mm. long, 6-8 mm. in diameter; tube just exceeding the calyx, may be tinted a deep velvety purple; lobes narrowly obcordate, about 3 mm. long, deeply emarginate; pompon of hairs in the throat coloured a deep purple. Stamens in short-styled flowers slightly exserted but hidden by the mass of hairs; style is about 1 mm. long, reaching the middle of the corolla-tube. Capsule not yet known.

The type is in the British Museum Herbarium and the species is represented in Edinburgh by:—

S.E. Tibet. Kashong La (*Ludlow and Sherriff*, 2350—*cotype*); Chubumbu La (*Ludlow, Sherriff and Taylor*, 3990); Tum La (*L., S. and T.*, 5791).

P. bella Franch. in Bull. Soc. Bot. Fr., xxxii, 268 (1885); Pax in Engl. Bot. Jahrb., x, 204 (1889); Forbes et Hemsl. in Journ. Linn. Soc., xxvi, 37 (1889); Pax in Engl. Pflanzenr. Primulaceae, 97 (1905); Balfour in Journ. Roy. Hort. Soc., xxxix, 132, 163, fig. 69 (1913); Gard. Chron., lxvi, 101, fig. 46 (1919); Stapf in Bot. Mag., t. 9145A (1928); Smith et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 15 (1928), and in Journ. Roy. Hort. Soc., liv, 29, fig. 27 (1929).

P. bella was first collected by Delavay in 1884 on the summit of Mt. Tsang-chan at an elevation of 4000 m. The locality is in the range of mountains immediately above the town of Tali. Delavay gathered it again in 1887 and material of both collections is in the Edinburgh Herbarium. The species appears to be abundant in many of the ranges of Western Yunnan and S.W. Szechwan, and subsequent explorers in this century have found it on numerous occasions. Franchet's diagnosis, published in 1885, is very exact and calls attention to certain points which are of moment for what follows: farina yellow; leaves long-petioled, with lamina ovate or suborbicular; peduncle about 3 times longer than leaves; bracts lanceolate or ovate-lanceolate, acute, entire or tridentate at apex; calyx-lobes acute or tridentate; corolla-tube shortly exceeding calyx, with the throat densely beset with hairs.

The collections of the last fifty years show that *P. bella* or something very like it occurs not only on the ranges of Western Yunnan but also in the extreme N.W. of that province, in S.W. Szechwan, in the Tibetan province of Tsarong, and in Northern Burma. The plants from the western ranges such as the Lichiang show reasonable conformity with those from the Tali Range. But as is to be expected, plants from the outlying regions exhibit some degree of deviation from the typical plant. These differences may be due in whole or in part to special environmental factors, but they have been commented on by experienced collectors in the field such as Forrest, Ward, Handel-Mazzetti, and Farrer who hesitated to regard all the plants as simply *P. bella*. Several of these divergent plants have been described as distinct species and *P. bella* quoted as the nearest affinity. The degree of difference varies considerably and the proper status of these additional "species" is not easy to determine. Smith and Forrest (*l.c.*) placed them all under *P. bella* as subspecies but without any detailed analysis. Franchet's original description, already referred to, permits of some variation in the typical plant from the Tali Range. The criteria relied on for separation of the subsequent species may be thus summarised: relative size, degree of development of the scape including ratio of scape to leaves, presence or absence of farina, colour of farina, occurrence of stolons, size and shape of bracts, and the shape of the calyx-lobes. Apart from size, little stress is laid on variation in the leaf and its serration or on the character of the corolla; both appear to be little modified if at all. Even with the additional material now available it has not been found possible to give a satisfactory assessment of these associates of *P. bella*, and they are here treated as subspecies with the caveat that they are not of equal grade and some may yet be reckoned as varieties or even forms. The problem calls for further and very detailed observation in the field and particularly on the variability of *P. bella* itself. The validity of the above-mentioned criteria will be referred to in the subsequent account of these subspecies.

Seed of *P. bella* was collected by Forrest in 1908 and the resulting plants flowered in May 1910 at Edinburgh. It remained in cultivation for some years but almost entirely from further sendings of Yunnan seed. It is readily raised from seed but reluctant to fruit under garden conditions in this country, and it is unlikely that any plants survive at this date.

The typical *P. bella*, as it occurs in matted formations on the Tali Range, is a graceful species 2·5–4 cm. high, with a flower often as large as the rest of the plant. There is a small rhizome more or less covered with the withered remains of old leaves; short leafy stolons frequently arise from the old stock. Leaves in a small rosette: blade obovate or suborbicular or spathulate, 3–7 mm. long, 3–5 mm. broad, rounded in outline at the apex, gradually narrowed into the winged petiole 3–7 mm. long, somewhat deeply incised at the margin into lanceolate or ovate teeth often recurved, glabrous, usually densely yellow-farinose below, more rarely whitish-farinose, with midrib and veins somewhat distinct. Scape slender, often flexuous, reaching 4 cm., slightly farinose; bracts 2, inserted close to the calyx, lanceolate or ovate, lower one smaller, upper sometimes as long as the calyx, acute but sometimes widened at the apex and there dentate; pedicels about 1 mm. long, farinose. Flowers generally solitary, often 2, rarely 3. Calyx tubular-campanulate, 4–6 mm. long, farinose or not, cut to the middle or a little beyond into deltoid-ovate or almost quadrate lobes acute or acuminate or sometimes blunt with an apiculus or even tridentate. Corolla salver-shaped, violet, purple or rose, glabrous without or rarely with a few whitish hairs; tube usually slightly exceeding the calyx but sometimes nearly twice as long, narrowly cylindric widening somewhat near the apex, hairy inside and with a dense white pompon projecting from the throat; limb flat, 2–2·5 cm. in diameter with obcordate deeply emarginate lobes. Stamens reaching the corolla-throat but hidden by the pompon or in long-styled flowers inserted near the base of the tube. Style 1·5 mm. long or in long-styled flowers reaching the corolla-throat. Capsule ellipsoid or shortly oblong, somewhat shorter than the calyx.

The type is in the Paris Herbarium. The species is well represented in Edinburgh by the following:—

YUNNAN. Tali Range (*Delavay—cotype* and in 1887); (*Forrest*, 1803, 1813, 6806, 11628); Lichiang (F. 10313); N.E. of the Yangtze bend (F. 10409); Chienchuan-Mekong divide (F. 23410); Mekong-Yangtze divide (F. 25702); Fuchuan Shan (F. 30229); (*Rock*, 16969); Wei Hsi (R. 17154); Haba Shan (R. 24790); Kin-tzu Shan (R. 25144).

SZECHUAN. Mount Konka (*Rock*, 16385); Mount Mitzuga (R. 16519); Kanshu Shan, S.W. of Muli (R. 24112).

S.E. TIBET. Seinghku (*Ward*, 6987); Zayul (W. 10550); Tsarong (*Rock*, 22992).

KEY TO SUBSPECIES OF THE P. BELLA AGGREGATE.

A. Distinctly farinose:
  B. Scape 2–3 times longer than leaves (S.W. China):
    C. Bracts ± lanceolate . . . . [*bella*]
    CC. Bracts ± orbicular . . . . *cyclostegia*
  BB. Scape very short ± immersed in leaves:
    C. Calyx-lobes lanceolate acuminate (Burma) . . . *sciophila*
    CC. Calyx-lobes broad apiculate (Yunnan) . . . . *nanobella*
AA. Efarinose or only obscurely farinose:
  B. Calyx-lobes ovate, abruptly apiculate (N.W. Yunnan) . . *Bonatiana*
  BB. Calyx-lobes ± lanceolate, acute (Burma) . . . . *coryphaea*

Subsp. **Bonatiana** (Petitm.) Smith et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 15 (1928); Journ. Roy. Hort. Soc., liv, 29 (1929). *P. Bonatiana* Petitm. in Bull. Herb. Boiss., vii, 525, fig. 3, II (1907); Stapf in Bot. Mag., t. 9145A (1928), as syn. *P. stragulata* Balf. f. et Forrest in Notes Roy. Bot. Gard. Edin., xiii, 20 (1920).

The only points in Petitmengin's diagnosis serving to some extent to distinguish his plant from *P. bella* are the efarinose leaves, the very short scape and the long corolla-tube. His type is *Soulié*, 1131 in Herb. Paris, collected on Mt. Sila in the region of the Upper Mekong. This is not at present available, but in the Edinburgh Herbarium is *Soulié*, 1471 secured on the same mountain. This shows some farina. Collections of Forrest and of Ward from the Tibetan province of Tsarong contain specimens in accord with the original description. Other specimens show a varying degree of farina but are otherwise similar. Stapf reduces the species to *P. bella*. But so far nothing quite like it has been recorded from the Tali and Lichiang Ranges. It may not merit specific rank but should retain a distinguishing name.

In the Edinburgh Herbarium are the following:—

S.E. TIBET. Ka-gwr-pu (*Forrest*, 14816); Salwin-Kiu-chiang divide (F. 18893—*type* of *P. stragulata*). From the same region but not typical are: *Forrest*, 480, 13937, 14285, 18722, 19530. Sila (*Soulié*, 1471). A-tun-tsu (*Ward*, 83).

Subsp. **coryphaea** (Balf. f. et Ward) Smith et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 15 (1928), and in Journ. Roy. Hort.

Soc., liv, 29 (1929). *P. coryphaea* Balf. f. et Ward in Notes Roy. Bot. Gard. Edin., ix, 15 (1915).

The habitat of this Burmese plant is given as "summit of granite mountain on bare patches of sandy soil" (*Ward*, from Nmai divide): "starring the grim grey granite" (*Ward*, from Imaw Bum): "mossy places on boulders on summit of Hpawshi Bum" (*Farrer*): "moist stony pasture" (*Forrest*, from Chimili). These collectors have usually refrained from equating this plant with *P. bella* by reason of the very dwarf habit, the almost invariable lack of farina, and the longer corolla-tube. It is thus not far removed from subsp. *Bonatiana* and may yet be combined with it when more complete evidence is available.

In the Edinburgh Herbarium are the following:—

UPPER BURMA. Nmai divide (*Ward*, 1805—*type*); Imaw Bum (W. 3388); Hpawshi Bum (*Farrer*, 1058); Chimili (*Forrest*, 24568, 26865, 27288).

Subsp. **cyclostegia** (Hand.-Mzt.) Smith et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 15 (1928), and in Journ. Roy. Hort. Soc., liv, 29 (1929). *P. cyclostegia* Hand.-Mzt. in Anz. Akad. Wiss. Wien, lvii, 87 (1920).

The type specimens of this plant in the Vienna Herbarium were collected by Handel-Mazzetti in 1914. The locality given is snowy depressions at 4400–4700 m. on Mt. Piepun in the Chungtien region where it was growing abundantly on limestone formations. The chief distinction given in the diagnosis as separating the plant from *P. bella* is the large orbicular bracts. The environmental factors prevailing on the Chungtien plateau are not believed to differ very markedly from those of the Tali and Lichiang Ranges. The collections made by Forrest on the limy pastures of the Chungtien show plants more robust than either *P. bella* or *P. cyclostegia*, for they sometimes reach 20 cm. Their bracts are large and are either broadly ovate or suborbicular. Assessment of all the material available favours the placing of the Chungtien plant in a subordinate status.

In the Edinburgh Herbarium there are the following:—

YUNNAN. Chungtien (*Handel-Mazzetti*, 4722—*cotype*, 6894); (*Forrest*, 10607, 11418, 12647).

Subsp. **nanobella** (Balf. f. et Forrest) Smith et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 15 (1928), and in Journ. Roy. Hort. Soc., liv, 29 (1929). *P. nanobella* Balf. f. et Forrest in

Notes Roy. Bot. Gard. Edin., xiii, 15 (1920); Stapf in Bot. Mag., t. 9145A (1928), as syn.

The type, *Forrest* 2399, was collected in 1906 on a patch of peaty soil on a barren limestone ridge, at the extreme limit of vegetation, on the eastern flank of the Lichiang Range, elevation 5300 m. The original diagnosis gives little in the way of differentiation from *P. bella*, except the small size, the very short scape, and the broad and somewhat obtuse bracts and sepals. Stapf (*l.c.*) includes it in *P. bella*, but in his text inclines to the view that the Lichiang Range plants do not quite coincide with typical *P. bella* and represent a slightly differentiated race. This dwarf plant, an extreme alpine, is here accorded a subspecific status which may well be above its right position.

In the Edinburgh Herbarium are the following:—

YUNNAN. Lichiang Range (*Forrest*, 2399—*type*, 5830, 15425).

Subsp. **sciophila** (Balf. f. et Ward) Smith et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 15 (1928), and in Journ. Roy. Hort. Soc., liv, 29 (1929). *P. sciophila* Balf. f. et Ward in Notes Roy. Bot. Gard. Edin., ix, 43 (1915).

This very dwarf Burmese plant has been found on only two occasions, once by Ward and once by Farrer. Ward records it from the Nwai divide, growing near or on granite cliffs at 4000 m. Farrer collected it only on the tops of the Shing Hong Pass at the same elevation. He adds this note: "This curious little plant might be *P. coryphaea* if it lacked farina or *P. moschophora* if it possessed a scape; it grows in loose wide flat masses of rosettes so minute that for a long time, until I came on the first blooms, I overlooked it as a mere mat of *Diapensia*. It occurs on open rocks and earth-pans of the high summits."

In habit and in size this plant recalls subsp. *nanobella*, but it is not the same. Farrer evidently regarded it as different from the other subspecies of Upper Burma and from *P. moschophora*. The somewhat scanty material supports his view.

In the Edinburgh Herbarium are the following:—

UPPER BURMA. Nwai divide (*Ward*, 1784—*type*); Shing Hong Pass (*Farrer*, 1624).

Of the subspecies quoted by Smith and Forrest in Notes Roy. Bot. Gard. Edin., xvi, 15 (1928), two are reduced to synonyms: *P. indobella* to *P. tenuiloba* and *P. stragulata* to *P. Bonatiana*.

P. moschophora Balf. f. et Forrest in Notes Roy. Bot. Gard. Edin., ix, 186 (1916); Cox in Plant Introd. Farrer, 73 (1930). *P. bella* Franch. subsp. *moschophora* Smith et Forrest, *ibid.*, xvi, 15 (1928), and in Journ. Roy. Hort. Soc., liv, 29 (1929).

This species was found by Forrest in 1913 on the Shweli-Salwin divide, West Yunnan, growing on moist stony pasture at an elevation of 3700 m. In the original diagnosis it was discriminated from *P. bella* by the long stolons and the white farina. Smith and Forrest (*l.c.*) gave it only subspecific rank. Further analysis of the material is entirely in support of Balfour's view. In addition to the above two criteria it may be noted that its area of distribution lies outwith that of *P. bella*, the leaves are of somewhat different shape, the two bracts are both sublinear, the corolla-tube is twice the length of the calyx and the pompon of hairs is much less pronounced. Its general aspect and its corolla-structure invite comparison with *P. flagellaris* and *P. tenella* rather than with *P. bella*. From these Himalayan species the development of the pompon and the pair of bracts serve to distinguish it. In reality it occupies an intermediate position and affords justification for the inclusion of section Bella within the Minutissimae. Still its relationship to *P. bella* is close enough, for Farrer who found it in Upper Burma thought he had secured *P. bella*, while Forrest, familiar with the latter plant, placed *P. moschophora* at first as a form of the Tali species. The collections quoted below are clearly conspecific and do not vary except in the degree of development of the pompon which is sometimes almost as prominent as in *P. bella*, but at other times represented by a mass of loose hairs in the corolla-throat.

P. moschophora is a dwarf farinose stoloniferous plant with a very short rootstock and girt at the base with the remains of old leaves: the naked flagellate stolons are 3–7 cm. long and terminated by a leafy bud. Leaves in a rosette and including the petiole at most 1·5 cm. long; lamina oblong, elliptic, obovate to subrhomboid or again narrowly spathulate, about 7 mm. long, 4 mm. broad, obtuse to rounded at the apex, attenuate into the winged petiole, deeply dentate at the margin, efarinose above but sprinkled with farini-potent glands, densely white-farinose below, with the midrib and 5–6 pairs of lateral nerves more or less conspicuous. Scape slender, farinose, at most 1·5 cm. high, usually 1-flowered, rarely 2–3-flowered; bracts 2, unequal, linear to linear-lanceolate, slightly farinose, the larger at the base of the calyx and about 3 mm. long, the smaller a little lower down. Calyx funnel-shaped to tubular-campanulate, 5–6 mm. long, slightly farinose within and without, strongly 5-nerved so as to appear 5-angled, cleft to the middle or a little lower into triangular to oblong-triangular lobes, acute at the apex and terminated by a hydathode. Corolla lilac to purplish-rose with a grey or yellowish eye; tube narrowly cylindric, twice as long as the calyx, exannulate, markedly villous at the throat and for some distance downwards, often forming a projecting pompon; limb 1–1·5 cm. in diameter, with obovate deeply emarginate lobes. Stamens in thrum-eyed flowers inserted at the mouth of the corolla-tube and about 2 mm. from the base in pin-eyed flowers. Long style equalling the corolla-tube: short style about half the length of the calyx. Capsule a little shorter than the calyx.

It is recorded as once in cultivation (Cox, *l.c.*). The species is represented in the Edinburgh Herbarium as follows:—

West Yunnan. Shweli-Salwin divide (*Forrest*, 12076—*type*, 15769, 17625, 29645): N'Maikha-Salwin divide (F. 17997, 18070); Chienchuan-Mekong divide (F. 23406).

Burma. Chimili Pass and Hpimaw Pass (*Farrer*, 879).

P. occlusa W. W. Sm.* Spec. nov.

P. pusilla Wall. var. *flabellata* W. W. Sm. in Notes Roy. Bot. Gard. Edin., xix, 173 (1936).

This close ally of *P. pusilla* was found by Ludlow and Sherriff in 1934 at Mago, S.E. Tibet, at an elevation just under 5000 m. It grows on banks on bare hillsides or in small closely set colonies on grassy cliff ledges. Represented at first by one collection only, it was described as a variety of *P. pusilla* as the difference in leaf-form may well have proved fortuitous. But in 1938 additional material was secured by Ward on the Le La which was in accord with the first collection. The species differs from its ally in the shape of the leaf and in the character of its serration, in the broader bracts, in the greater tendency to solitary flowers and these often larger and in the much longer corolla-tube. It has not been in cultivation.

A small plant 2·5–5 cm. high, with a short comparatively stout rhizome, girt at the base with the remains of old leaves. Leaves in a little rosette often no larger than the flower, including the petiole up to 15 mm. long, 7 mm. broad, flabelliform or suborbicular, rounded at the apex, quickly narrowed into the petiole usually much shorter than the blade, serrate-dentate in the upper half, covered above and on the veins below with short white septate hairs giving the leaf a markedly scabrid appearance, generally efarinose but occasionally with a small patch of farina; midrib and veins somewhat prominent below. Scape at most 5 cm. tall, faintly farinose towards the apex, with usually 1, occasionally 2, rarely 3 sessile flowers; bracts leafy, 2–3, sometimes as long as the calyx and almost concealing it, sometimes shorter, broadly ovate, deeply toothed and occasionally almost lobed, strongly nerved and sparingly farinose within and without. Calyx green, campanulate, 4–5 mm. long, farinose, cleft to the middle into ovate to oblong lobes, rounded at apex and there often with an apiculus. Corolla purplish-mauve, violet or purple, with a white eye, sometimes slightly farinose; tube usually twice as long as the calyx; throat occluded with a pompon of white septate hairs extending some distance inside; limb up to 1·5 cm. in diameter, with obcordate deeply emarginate lobes. Stamens inserted slightly below the throat in thrum-eyed flowers and near the middle of the tube in pin-eyed. Long style scarcely equalling the corolla-tube, short style hardly as long as the calyx.

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* Species valde affinis *P. pusillae* Wall. a qua foliis nec spathulatis nec oblanceolatis sed potius flabelliformibus vel nunc suborbicularibus, haud pinnatifido-dentatis sed dimidio superiore serrato-dentatis, bracteis latioribus, corollae tubo calycem plus minusve duplo superante differt.

In the Edinburgh Herbarium are:

S.E. TIBET. Mago (*Ludlow and Sherriff*, 725—*type*); Le La (*Ward*, 14140).

P. pusilla Wall. in Roxb. Fl. Ind. (ed. Carey and Wall.), ii, 22 (1824); Wall. Tent. Fl. Nepal., t. 32 (1824–26); Duby in Mém. Soc. Phys. et d'Hist. Nat., x, t. 1, fig. 2 (1848), and in DC. Prodr., viii, 42 (1844); Hook. f. Fl. Brit. Ind., iii, 492 (1882); Pax in Engl. Bot. Jahrb., x, 188 (1889), and in Engl. Pflanzenr. Primulaceae, 69 (1905); Hook. f. in Bot. Mag., t. 7079 (1889); Smith in Rec. Bot. Surv. Ind., iv, 219, 393 (1911–13); Smith et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 15 (1928), and in Journ. Roy. Hort. Soc., liv, 29 (1929). *Androsace primuloides* D. Don, Prodr. Fl. Nepal., 81 (1825). *Androsace primulina* Spreng. Syst. Veget., iv, 1, Cur. post. 57 (1827). *Primula humilis* Steud. Nom., ed. 2, ii, 205 (1841).

P. pusilla is a common plant of the Eastern Himalaya at elevations of 4000–5000 m. throughout Nepal, Sikkim, and Bhutan. It has also been found in S. and S.E. Tibet. Hooker in Bot. Mag. (*l.c.*)

records it from Kumaon: in Duthie's Cat. Plants of Kumaon 104 (1906) it is included with a query, but a single fruiting specimen in Herb. Dehra Dun under *Duthie* 3138 is the species. West of Nepal it is probably rare. Hooker further notes that it is remarkable for its never varying from the type throughout its wide range. Brought back by Wallich from his expedition into Nepal, it was the first member of the section to be described and figured. The nearest ally is *P. occlusa*; its affinity with *P. bella* is much more remote. Pax (*l.c.*) placed it in his section Soldanelloideae, but the form of the corolla is against that allocation. Its first introduction to cultivation appears to be by seed sent to Kew in 1886, with plants flowering in 1888. Since that time it has been raised from fresh seed on various occasions, but does not long persist as the plants are apt to die out without producing mature fruits.

P. pusilla is an erect little plant of 2·5-8 cm., with many leaves in a close rosette, girt below with remains of older leaves and with a short but fairly stout rhizome. Leaves including the petiole 1–3 cm. long, 3–5 mm. broad, spathulate or oblanceolate, coarsely pinnatifidly toothed, rounded in outline at the apex but with projecting teeth, gradually narrowed into the winged petiole sometimes equal to the blade but usually much shorter, efarinose, minutely scabrid-pilose above and chiefly on the veins below; midrib and 5–6 pairs of lateral nerves somewhat prominent on the lower surface. Scape at most 8 cm. high, sparingly farinose towards the apex, carrying usually 2-4 sessile or almost sessile flowers, but occasionally single flowers; bracts up to 4 mm. long, ovate-lanceolate, acute or sometimes toothed at apex, finely puberulous or farinose. Calyx 3–4 mm. long, campanulate, cleft to about the middle into triangular acute lobes, finely puberulous or white-farinose. Corolla purple or violet, rarely white; tube short, scarcely exceeding the calyx, hoary pubescent or finely farinose outside and the throat occluded with a dense pompon of white hairs; limb 8-10 mm. in diameter with obcordate emarginate lobes. Stamens inserted just below the pompon, or near the base of the corolla-tube in the case of long-styled flowers. Long style almost reaches the corolla-throat; short style slightly less than the calyx, as is also the ovoid capsule.

This readily recognisable species is well represented in herbaria. The following are cited from the Edinburgh Herbarium as typical:—

NEPAL. Gossain Than (*Wallich*, 609—*cotype*); Michet (*Lal Dhwoj*, 7, 8, 132); (*Sharma*, 346, 395, 441).

SIKKIM. *Hooker*; Jongri (*Watt*, 5794); Tankra La (*Gammie*, 491); Lampokri (*Cave*, 7344); Sheraothang (*Cooper*, 139).

BHUTAN. On the Rudo La (*Ludlow and Sherriff*, 294); Pang La (*L. and S.*, 464); Narim Thang (*L. and S.*, 483); Dungshinggang (*L. and S.*, 3270); Changsethang (*L. and S.*, 3402).

S.E. TIBET. Near Tawang (*Ludlow and Sherriff*, 665).

THE GENUS PRIMULA: SECTION MUSCARIOIDES. By W. WRIGHT SMITH and H. R. FLETCHER.

(Read 23rd April 1942.)

In his analysis of the Chinese species of Primula at the 1913 Primula Conference (Journ. Roy. Hort. Soc. London, xxxix, p. 130) Sir Isaac Bayley Balfour grouped together nine species of Primula which are thus characterised: All have small tubular flowers assembled in a compact spike or in a capitulum, with the mouths of the corollas usually pointing downwards. The posterior side of the flower is more developed than the anterior especially in the calyx where the posterior lobes are larger than the anterior ones. In the flower-bud the two posterior calyx-lobes cover the rest of the flower and the overlapping of these lobes gives the surface of the immature spike an imbricate look, like a tiled roof. The flowers open from the base of the spike upwards, so that as flower expansion proceeds a cluster of deflexed flowers, usually blue or purple, are surmounted with a cone of unopened flowers, the bracts and calyces of which are usually green or dark purple or as in *P. Viali* a bright scarlet.

To this group Balfour gave the sectional name Muscarioides to include the following species: *P. cernua* Franch., *P. deflexa* Duthie, *P. Giraldiana* Pax, *P. gracilenta* Dunn, *P. Littoniana* Forrest, *P. pinnatifida* Franch., *P. Viali* Delavay ex Franch., *P. Watsoni* Dunn, all of which are Chinese, and the Himalayan *P. bellidifolia* King. Thus *P. pinnatifida* and *P. cernua* were transferred from Pax's section Soldanelloideae, and *P. Giraldiana*, *P. Viali*, and *P. bellidifolia* from his section Capitatae. Balfour's section should have included one other species, *P. muscarioides* Hemsl. This plant had been introduced into cultivation from seed collected by Forrest, but Balfour believed it to be *P. Giraldiana*, though he had not seen the latter and had to base his opinion on the original description and figure. There can be no doubt but that the two species are quite distinct. From 1913 onwards large collections of the genus were secured by Forrest, Cooper, Ward, Farrer, Purdom, and Maire, and the following were described as new and added to the section: from Forrest came *P. lepta* Balf. f. et Forrest, *P. conica* Balf. f. et Forrest, *P. apoclita* Balf. f. et Forrest, *P. cyanantha* Balf. f. et Forrest, *P. tsarongensis* Balf. f. et Forrest; Cooper sent from Bhutan *P. Menziesiana* Balf. f. et W. W. Sm., *P. adenantha* Balf. f. et Cooper, *P. atricapilla* Balf. f. et Cooper, *P. micropetala* Balf. f. et

Cooper; Ward collected *P. euchaites* W. W. Sm., *P. concholoba* Stapf et Sealy, *P. hyacinthina* W. W. Sm., *P. violacea* W. W. Sm. et Ward; from Farrer and Purdom came *P. aerinantha* Balf. f. et Purdom and from Maire *P. cephalantha* Balf. f. and *P. Mairei* Lévl. The descriptions of most of the above were based on the first sendings which were often meagre, and it is now clear that many of the specific names must be regarded as merely synonyms. In the intervening years the western provinces of China and the Eastern Himalaya have been more fully explored and the geographical distribution of many of the species considerably extended. This factor has tended to bring together plants previously isolated and regarded as distinct but now evidently conspecific. The short account given of the section by Smith and Forrest (Notes Roy. Bot. Gard. Edin., xvi, 28 (1928)) was directed to assembling the presumed members rather than to an assessment of the status of each species. The material now available with experience of some of the species in cultivation has solved many problems, and the names considered by the present authors as reasonably valid are given on p. 270. But amongst these are some, such as *P. Mairei* and *P. hyacinthina*, which require more evidence for confirmation.

The section is very closely allied to Capitatae and to Soldanelloideae. In *P. capitata* Hook. and its allies the flowers are aggregated in a round capitular truss; those of the Muscarioides on the other hand are arranged in more of a spike, which in exceptional cases such as the giant form of *P. Viali* may be a foot or more in length. The shape and droop of the flowers in the two sections is more or less the same and both sections show the same apical crown as the flowers expand from below upwards. The flowers of the Muscarioides section are sessile; those of Capitatae shortly stalked. This is important for in the Muscarioides downward curvature takes place in the calyx and corolla, and consequently the posterior side of the flower is more strongly developed. In the Capitatae downward curvature takes place in the pedicels and not in the flower itself, so that the latter is quite regular. The two sections can also be distinguished by their vegetative characters. The leaves of the Muscarioides are of softer texture, equipped with more or less numerous long articulate hairs and nearly always efarinose. In the Capitatae the leaves are firm in texture, show no articulate hairs, and are usually but not always farinose. Genetically the two are distinct, for the basic number of chromosomes in Capitatae is 9 and that of Muscarioides 10. Ten is also the basic chromosome number of Soldanelloideae, and the nuclei of the species of these two sections cannot be separated by cytological means. The shape of the corolla, however, is usually a sufficient diagnostic mark. In Muscarioides the corolla-tube is usually much longer and is more conspicuous than the limb: the latter with its short lobes is more or less patent and thus at a right angle with the tube. In Soldanelloideae the corolla-tube is almost invariably short and much less prominent than the inflated limb; the latter is expanded into a broad bell, with the lobes preserving the bell outline and not becoming patent or bent back.

The section is distributed over the Eastern Himalaya, Tibet, and Western China and several of the species are in cultivation. Though *P. muscarioides*, *P. bellidifolia*, *P. apoclita*, *P. deflexa*, *P. cernua*, *P. Watsoni*, *P. pinnatifida*, *P. hyacinthina*, and *P. concholoba* have been and may still be in cultivation, by far the most successful is *P. Viali*, better known as *P. Littoniana*.

In general habit the members of the section recall *P. capitata* Hook. and its allies, but tend to be less robust and occasionally dwarf. The rhizome is weakly developed, yet in their native habitat they can be regarded as perennial to a limited extent. In cultivation they are short-lived, rarely persisting after flowering; some seed freely, such as *P. Viali*, and these are the likely survivors in culture. The leaves show great variation in the degree of lobing, for they may be almost entire, crenate or serrate or dentate, in some cases deeply pinnatifid: this last condition is pronounced in *P. pinnatifida* var. *sectilis* where they are bipinnatifid to a degree very unusual in the genus; as already noted they are furnished with long articulate hairs, are usually elliptic or lanceolate in outline, rarely obovate, with a more or less blunt apex, decurrent into somewhat short petioles and thus forming a rosette, but the petioles are sometimes elongate, particularly when the plants are in fruit; only rarely are the leaves farinose and almost glabrous. The scape, stout or flexuous, is terminated by a spike or capitulum with usually numerous flowers; in fruit the axis of the capitulum tends to elongate into a short spike. The flowers are sessile and usually pendent. The imbricated bracts form a cone-like cover to the flowering spike and a flatter crown to the flowering capitulum. Normally the calyx is very much shorter than the corolla-tube and is irregular in shape owing to the greater development of the posterior lobes. For the size of the flower the exannulate corolla-tube is markedly elongate and the lobes short by contrast; the lobes may be entire, emarginate or somewhat more deeply cleft. The relative positions of stamens and styles are in accord with the normal heteromorphic arrangement except in *P. concholoba* which is monomorphic. The globular ovary develops into a shortly oblong capsule, equalling or somewhat exceeding the calyx and opening by five apical valves. The seeds average 0·5 mm. in diameter, are irregularly cubical and covered with brownish vesicular protuberances. The capsules and seeds of this section are in general conformity with those of the allied sections Capitatae, Denticulata, and Soldanelloideae.

The following species are contained in the section:—

P. aerinantha *Balf. f. et Purdom.*
P. apoclita *Balf. f. et Forrest.*
    P. lepta Balf. f. et Forrest.
P. bellidifolia *King.*
    P. adenantha Balf. f. et Cooper.
    P. atricapilla Balf. f. et Cooper.
    P. Menziesiana Balf. f. et W. W. Sm.
    M. micropetala Balf. f. et Cooper.
P. cernua *Franch.*
P. concholoba *Stapf et Sealy.*
P. deflexa *Duthie.*
    P. conica Balf. f. et Forrest.
P. euchaites *W. W. Sm.*
P. Giraldiana *Pax.*
P. gracilenta *Dunn.*
P. hyacinthina *W. W. Sm.*
P. inopinata *Fletcher.*
P. Mairei *Levl.*
    P. cephalantha Balf. f.
P. muscarioides *Hemsl.*
    P. tsarongensis Balf. f. et Forrest.
P. pinnatifida *Franch.*
    var. nana *Balf. f. mss.*
    var. sectilis *Balf. f. mss.*
P. Viali *Delavay ex Franch.*
    P. Littoniana Forrest.
    P. Littoniana Forrest var. *robusta* Forrest.
P. violacea *W. W. Sm. et Ward.*
P. Watsoni *Dunn.*
    P. cyanantha Balf. f. et Forrest.

KEY TO THE SPECIES.

A. Flowers in loose interrupted raceme . . . . . . *inopinata*
AA. Flowers in dense spikes or capitula:—
B. Corolla-lobes acute and often apiculate, rarely obtuse, never emarginate:—
C. Bracts and calyx crimson; flowers in very elongate spikes; scapes glabrous . . . . *Viali*
CC. Bracts and calyx green to black; flowers in capitula or short spikes; scapes hairy . . . . *gracilenta*
BB. Corolla-lobes never acute but round, emarginate, crenulate or lobulate:—
C. Leaves scabrid-pubescent on both sides . . . . *violacea*
CC. Leaves with long articulated hairs or sometimes almost glabrous:—
D. Corolla-tube hardly longer than the calyx; limb subglobose; lobes concave; (homostyled) . . . . . *concholoba*
DD. Corolla-tube at least twice as long as calyx; limb funnel-shaped:—
E. Inflor. ± capitate; relatively few-flowered (5–15); flowers not all pendent-reflexed but many horizontal:—
F. Scape, calyx, and bracts hairy; inflor. 5-fld. efarinose; (Burma-Tibet frontier) . . . . . . *euchaites*
FF. Scape ± glabrous; calyx and bracts ± ciliate; inflor. usually 10–15 fld. ± farinose:—
G. Cor. lobes deeply cut to ⅓ length; inside of cor. limb efarinose; (Kansu) . . . . *aerinantha*
GG. Cor. lobes entire or slightly notched; inside of cor. limb farinose:—
H. Cor. lobes entire; calyx lobes acute; (Shensi). *Giraldiana*
HH. Cor. lobes slightly notched; calyx lobes obtuse; (E. Himalaya and S.E. Tibet):—
I. Leaves efarinose . . . . . . *bellidifolia*
II. Leaves white-farinose below . . . *hyacinthina*
EE. Inflor. ± spicate; usually many-fld. (10–100); fls. all markedly pendent-reflexed; (Szechwan, Yunnan):—
F. Leaves ± entire, obovate with broad rounded apex, ± sessile; cor. limb almost as broad as tube is long *cernua*
FF. Leaves crenate, dentate to deeply incised, usually elliptic to lanceolate; cor. limb far from being as broad as the tube is long:—
G. Cor. lobes ± erect, in line with tube; cor. cylindric, only slightly dilated at apex, deep indigo-purple . *Watsoni*
GG. Cor. lobes patent; cor. infundibular, with apical dilation, mauve, violet or purplish-blue:—
H. Leaf margin strongly crenate-serrate to crenate-dentate:—
I. Leaves 10–20 cm., shining, sparsely hairy; inflor. ± efarinose:—
J. Scape hairy; leaves everywhere sparsely hairy; inflor. efarinose . . . . . . *deflexa*
JJ. Scape glabrous; leaves hairy on midrib below; inflor. sometimes farinose . . . *muscarioides*
II. Leaves 5–10 cm., matt, everywhere very hairy; inflor. ± yellow-farinose; scape glabrous . *apoclita*
HH. Leaf-margin deeply incised-lobulate or pinnatifid or very coarsely dentate:—
I. Under-surface of leaf shining, with hairs confined to midrib; (W. Yunnan) . . . . . *pinnatifida*
II. Under-surface of leaf matt, everywhere hairy; (E. Yunnan) . . . . *Mairei*

P. aerinantha Balf. f. et Purdom in Notes Roy. Bot. Gard. Edin., ix. 146 (1916); W. W. Sm. et Forrest, *ibid.*, xvi, 29 (1928), and in Journ. Roy. Hort. Soc. London, liv, 36, fig. 36 (1929); Cowan in Bot. Mag., t. 8922 (1938).

P. aerinantha is a Western Kansu plant, at first thought to grow in one locality only, in a big gully on Lotus mountain (Lien Hwa), where it was discovered by Purdom at altitudes of 3000–4000 m. in 1911. In 1914 Purdom and Farrer again secured it, this time in fruit, and from the seeds they collected the plant flowered for the first time in cultivation at Edinburgh in 1916. Finally in 1925 Rock visited the same locality and collected flowering specimens. He records that the habitat of this Primula is not so restricted as was at first supposed, and that it is not confined entirely to limestone rocks but occurs also in alpine meadows. The species is usually compared with *P. cernua* to which in foliage characters there is some resemblance, but the relatively sparse inflorescence and the structure of the individual flowers appear to indicate *P. Giraldiana* and *P. gracilenta* as closer allies.

Leaves in clusters, with the blades oblong to elliptic, up to 5 cm. long and 2·5 cm. wide, sparsely and shortly hairy both above and below, distinctly crenate-dentate at the margin, rounded or obtuse at the apex, and quickly tapering into the winged petiole 1·5–4 cm. long. Scape up to 30 cm., puberulous, white-farinose towards the apex, carrying a head or short spike of 3–15 lavender-blue flowers which arise from the axils of small lanceolate green or purple-tinged ciliate farinose bracts. Calyx cup-shaped, 3 mm. deep, divided more or less to the middle into ovate lobes, subacute at the apex and glandular-ciliate at the margin. Corolla-tube in short-styled flowers narrow-cylindrical, about 8 mm. long, inflated opposite the anthers, expanding abruptly into the efarinose limb with deeply notched lobes, 4 mm. long and 4 mm. broad. Stamens with anthers 1·5 mm. long inserted 8 mm. above the base of the corolla-tube; style 2 mm. long. Capsule ovoid, half-enclosed by the persistent calyx lobes, splitting into 5 concave valves.

The type material, *Purdom* 738, is in the Kew Herbarium and the plant is represented in Edinburgh by:—

Western Kansu. Lien Hwa—Lotus Mountain (*Farrer*, 273); Lien Hwa Shan, between Taochow and Titao (*Rock*, 12676, 12711).

The species flowered in the Royal Botanic Garden, Edinburgh, in 1916–1918, but was very soon lost to cultivation. It proved easy to raise from native seed, but the resultant plants were short-lived and produced no ripe capsules.

P. apoclita Balf. f. et Forrest in Notes Roy. Bot. Gard. Edin., xii, 3 (1920); W. W. Sm. et Forrest, *ibid.*, xvi, 29 (1928), and in Journ. Roy. Hort. Soc. London, liv, 35, 36 (1929); Gould, *ibid.*, liv, 73 (1929). *P. lepta* Balf. f. et Forrest in Notes Roy. Bot. Gard. Edin., xii, 12 (1920); W. W. Sm. et Forrest, *ibid.*, xvi, 29 (1928), and in Journ. Roy. Hort. Soc. London, liv, 35 (1929); Hand.-Mzt., *ibid.*, liv, 59 (1929).

A denizen of moist stony alpine pastures, *P. apoclita* is very nearly allied to *P. muscarioides* Hemsl. It is, however, a much less robust plant than that species, with smaller more hairy matt leaves and with a shorter flower-scape which is always markedly farinose on the upper half and not efarinose as is usually the case in the other species. Moreover, the calyx-lobes are farinose and ciliolate, whereas those of *P. muscarioides* are, as a rule, efarinose and non-ciliolate. In size and in the character of the inflorescence, *P. apoclita* is also closely related to *P. pinnatifida* Franch. and to *P. Mairei* Lévl., but its leaves are very much less cut.

Forrest found *P. apoclita* on Ka-gwr-pu, Mekong-Salwin divide in S.E. Tibet, at an altitude of 4000 m. in 1917. In Yunnan during July of the following year he collected on the mountains N.E. of Chungtien and at the higher altitude of 4700 m. plants obviously closely allied to *P. apoclita*, but less in stature, and with smaller somewhat less indented leaves. These plants were described under the name of *P. lepta*. Since that time much new material has become available from S.E. Tibet and from S.W. Szechuan which convincingly shows that Forrest's Yunnan plant cannot now be upheld as a distinct species.

P. apoclita has leaves usually 3–5 cm. long, occasionally up to 12 cm., 1–1·5 cm. broad, oblong-spathulate to oblong or elliptic, rounded at the apex, rapidly tapering into the winged petiole which is generally very short though sometimes well developed, regularly crenate-serrate to crenate-dentate at the margin, and lightly covered with hairs above and below. Scape up to 16 cm. tall, yellow-farinose on the upper half, carrying a short spike or head of reflexed fragrant flowers supported by lanceolate farinose and ciliolate bracts. Calyx cup-shaped, about 3–4 mm. long, yellow-farinose, unequally lobed to the middle. Corolla deep purplish-blue, about 12 mm. long, with the tube 7 mm. long, widening upwards into the limb; lobes 2–3 mm. long, 3–3·5 mm. broad, faintly notched or crenulate at the apex. In pin-eyed flowers stamens inserted 2·5–3 mm. above the base of the corolla-tube; style 6 mm. long.

In the Edinburgh Herbarium there are the following collections:—

S.E. TIBET. On Ka-gwr-pu, Mekong-Salwin divide (*Forrest*, 14201—*type*, 14820); on the Sie la (F. 15048, 20769); Londre Pass (F. 19522); Mekong-Salwin divide (F. 14382); Salwin-Kiu-Chiang divide (F. 18993, 21794). Also *sine loc.* (F. 18727).

S.W. SZECHUAN. Mountains W. of Muli (*Forrest*, 28363). Muli (*Ward*, 4622, 4651); Litang River divide, Yung-ning (W. 4180); Litang-Yalung divide (W. 4383). Mount Konka, Risonquemba, Konkaling (*Rock*, 16291); Dzampe Sheren (R. 23807); Moting Shan (R. 22770).

YUNNAN. Mountains N.E. of Chungtien (*Forrest*, 16475—*type* of *P. lepta*); Haba Shan (F. 30207); Chienchuan-Mekong divide (F. 23402, 23403).

Plants grown from seeds of *Forrest* 19522 flowered in 1924, and the species has been in cultivation since at Edinburgh and elsewhere.

P. bellidifolia King ex Hook. f. in Fl. Brit. Ind., iii, 486 (1882); Pax in Engler's Pflanzenr. Primulaceae, 95 (1905); Dunn in Notes Roy. Bot. Gard. Edin., v, 62, 63 (1911); Watt in Journ. Roy. Hort. Soc. London, xxix, 298 (1904), and *ibid.*, xxxix, 199, 204, 206, 207 (1913); Craib, *ibid.*, xxxix, 187, 188 (1913); W. W. Sm. et Forrest, *ibid.*, liv, 35, 36 (1929), and in Notes Roy. Bot. Gard. Edin., xvi, 29 (1928); Bot. Mag., t. 8801 (1909). *P. Menziesiana* Balf. f. et W. W. Sm. in Notes Roy. Bot. Gard. Edin., ix, 182 (1916); McLaren in Journ. Roy. Hort. Soc. London, liv, 66 (1929); Cowan in Bot. Mag., t. 8916 (1938). *P. adenantha* Balf. f. et Cooper in Notes Roy. Bot. Gard. Edin., xiii, 2 (1920). *P. micropetala* Balf. f. et Cooper in *ibid.*, xiii, 14 (1920). *P. atricapilla* Balf. f. et Cooper in *ibid.*, xiii, 4 (1920); McLaren in Journ. Roy. Hort. Soc. London, liv, 66 (1929); Gould, *ibid.*, liv, 73 (1929).

This species was found by Sir George King's collectors in the Sikkim Himalaya and in the Chumbi Valley, Tibet, in 1877. Its distribution has in recent years been extended into S.E. Tibet and Bhutan. In 1914–15 Cooper collected it in Bhutan and his material, as also the plants raised from his seed, did not at first appear to be quite homogeneous, and consequently several specific names were published. It is now recognised that all are referable to *P. bellidifolia*. The plant called *P. Menziesiana* is more robust, with larger flowers, but in cultivation merges into typical *P. bellidifolia*. However, it should be noted that in *P. bellidifolia* the diploid number of chromosomes is 20, whereas the diploid phase of *P. Menziesiana* has 40 chromosomes. But as it has not been found possible to detect a constant morphological character to correspond to this cytological difference. *P. Menziesiana* has been reduced to the older species, but if need be the name could be retained to signify a varietal deviation. It is also to be noted that very occasionally there is a development of farina at the stock and at the base of the leaves in *P. bellidifolia*. This implicates the position of its nearest ally *P. hyacinthina* and it is a moot point whether the latter is to be deemed a highly farinose member of the same specific aggregate.

Leaves oblanceolate to spathulate, rounded at the apex, narrowed into the winged pubescent petiole, 4–15 cm. long, 1–2·5 cm. broad, adpressed-setulose-pubescent on both surfaces and shallowly dentate or crenate at the margin; in their shape and dull matt surface they suggest those of the common daisy as the specific name implies. Scape glabrous or slightly hairy, 10–35 cm. high, farinose towards the apex, bearing a head of usually 7–15 flowers, reflexed and supported by small bracts. Calyx campanulate, covered, sometimes rather sparingly so, within and without with white farina, about 5 mm. long, lobed almost to the base, the lobes being oblong-elliptic, rounded or broadly obtuse at the apex and papillosely ciliate at the margin. Corolla mauve to pale blue-violet, with a ring of farina at the throat; tube 5–10 mm. long, rather darker than the limb; lobes obovate and conspicuously emarginate. In thrum-eyed flowers stamens inserted in the upper half of the corolla-tube; style barely 2 mm. long. Capsule ovoid, much longer than the calyx, dehiscing by 5 valves.

SIKKIM HIMALAYA. Yakla (*Cooper*, 732); Zemu valley (*Smith and Cave*, 1624); without precise locality (*Native Collector*, 1891, 1988); above Changu (*Cave*, s.n.).

TIBET. Chumbi (*King's Collector*, 4564—*cotype*); Dotha, Chumbi valley (*Ribu and Rhomoo*, 165); Chumolari, Chumbi valley (*R. and R.*, 510); Temo La (*Ward*, 5760); Nam La (W. 5970, 6004); Mago (*Ludlow and Sherriff*, 720); Cha La, Dongkar (*L. and S.*, 849); Dza La, 25 m. E. of Tsona (*L. and S.*, 701); Tulung La, 30 m. S.E. of Tsona (*L. and S.*, 707); Bimbi La, Kyim Dong Chu (*L. and S.*, 1801); Kulu Phu Chu, near Paka (*Ludlow, Sherriff and Taylor*, 5966, 6515); Tse, Tsangpo Valley (*L. S. and T.*, 6004).

BHUTAN. Philey La (*Cooper*, 3470—*type* of *P. Menziesiana*);

(C. 1771—*type* of *P. atricapilla*); Barshong (C. 1890—*type* of *P. adenantha*); Timbu (C. 1601, 1645); Joedawnchi (C. 4855); Hoopkge La (C. 4056—*type* of *P. micropetala*); Orka La, Sakden (*Ludlow and Sherriff*, 636); Dungshinggang, Black mountain (*L. and S.*, 3288); Changuthang, Mangde Chu (*L. and S.*, 3409).

Since 1915, when Bees Ltd. first brought plants to flowering stage from Cooper's seed, *P. bellidifolia* has been more or less continuously in cultivation. As it comes from altitudes of 4000–5300 m. one would expect it to be hardy in cultivation, but it resents the dampness of our winter climate. In 1928 Mr. R. C. Notcutt gained an Award of Merit at the Royal Horticultural Society's April Show, for plants exhibited under the name of *P. Menziesiana*.

P. cernua Franch. in Bull. Soc. Bot. Fr., xxxii, 271 (1885); Pax in Engler's Bot. Jahrb., x, 193 (1889); Forbes et Hemsl. in Journ. Linn. Soc. Bot., xxvi, 37 (1889); Pax in Engler's Pflanzenr. Primulaceae, 66 (1905); Dunn in Notes Roy. Bot. Gard. Edin., v, 62, 64 (1911); Balf. f. in Journ. Roy. Hort. Soc. London, xxxix, 132, 152 (1913); W. W. Sm. et Forrest, *ibid.*, liv, 35 (1929), and in Notes Roy. Bot. Gard. Edin., xvi, 29 (1928).

P. cernua is one of the most distinct members of the section. It is well characterised by the obovate subentire leaves which are often subsessile and by the widespread limb in marked contrast to the relatively small limb of most Muscarioides. It was one of the discoveries near Tali of Abbé Delavay in 1883, and the type plant (unnumbered) is in the Paris Herbarium. Apart from a further collection of Delavay in 1886 nothing seems to have been heard of the plant until Forrest rediscovered it on the Hoching-Langkong dividing range in 1910 and in subsequent years extended its range from Yunnan into S.W. Szechuan at elevations of 2500–4000 m.

Leaves obovate to ovate, 3–12 cm. long, 1·5–4 cm. broad, rounded or faintly emarginate at the apex, rapidly tapering into the short winged petiole sometimes almost obsolete, entire or more or less crenulate and ciliate at the margin, thinly covered above and below with white articulated hairs more numerous in the region of the veins. Scape 15–40 cm. tall, puberulous on the upper half, white-farinose at the apex. Flowers arranged in heads or in short spikes up to 4 cm. long; bracts ovate, slightly farinose and ciliate. Calyx cup-shaped, about 4 mm. long, divided into ovate lobes, 1·5–2 mm. long, 2 mm. broad, rounded and then suddenly acute at the apex, faintly ciliate, farinose both within and without. Corolla deep purplish-blue, faintly farinose and puberulous without, 17–18 mm. long; tube 11-12 mm. long, gradually widening into the limb; lobes ovate to oblong, 4 mm. long, 3 mm. broad, emarginate or slightly sinuate at the apex. In thrum-eyed flowers stamens, with anthers 1 mm. long, inserted near apex of corolla-tube; style 2 mm. long.

In the Herbarium this species is thus represented:—

YUNNAN. Near Hee-gni-chao, on the road to Hokin (*Delavay*, s.n.): Hoching-Langkong dividing range (*Forrest*, 6132); mountains N.W. of Chienchuan (F. 12775); Chienchuan-Mekong divide (F. 21957).

S.W. SZECHUAN. Muli mountains (*Forrest*, 16831, 22140); mountains between Yung-peh and Yung-ning (F. 22053, 22458); mountains between the Litang and Yalung rivers (*Rock*, 16614): mountains between Wa-Erh-Dje and Muli Gomba (R. 16915); between Baurong and Kulu (R. 17851): mountains of Kulu (R. 18023).

This is a rare plant in cultivation and at this date probably lost. In 1928 at the Royal Horticultural Society's April Show, Mr. C. T. Musgrave received an Award of Merit for a flowering specimen of this species.

P. concholoba Stapf et Sealy in Bot. Mag., t. 9289 (1932). *P. apoclita* Ward in Gard. Chron., Ser. 3, lxxxiii, 84 (1928), and in Ann. Bot., xliv, 117 (1930)—non Balf. f. et Forrest.

This quite distinct species with its very short corolla-tube and concave conniving corolla-lobes, was discovered by Ward in the valley of the Seinghku on the Assam-Burma-Tibet frontier in 1926, growing on steep grassy slopes and on cliff ledges, amongst dwarf Juniper and Rhododendron, at an altitude of about 4000 m.

The species was described from a cultivated plant raised at Kew from seeds collected by Ward in the Seinghku valley (W. 6975). The herbarium specimen of this number had previously been identified as *P. apoclita* Balf. f. et Forrest, a plant not unlike in foliage; the characters of the flower as seen in the living state leave no doubt as to its distinctness from that species. Ward has collected *P. concholoba* also in the Delei valley, which is in the basin of the Brahmaputra. It is also recorded from S.E. Tibet. The first and only introduction of this species was in 1926–28 from Ward's seeds. It flowered at Kew, Edinburgh, and other gardens but did not receive a definite name until described in the Botanical Magazine in 1932. At this date it is still in cultivation but sparingly, and has the same chances of survival as most Muscarioides with the exception of the more amenable *P. Viali*.

Leaves 2–8 cm. long, 1–2 cm. broad, oblanceolate-oblong to oblong, rounded at the apex, long-attenuate into the long or short and more or less winged petiole, coarsely and irregularly dentate at the margin, slightly rugose and softly hairy above, hairy all over below or hairs confined to mid-rib and lateral nerves. Scape 7–20 cm. high, glabrous, slightly farinose, carrying a globose compact head, about 2 cm. in diameter, of 10–20 flowers: bracts linear, acute, more or less farinose, up to 5 mm. long. Calyx cup-shaped, 4–5 mm. long, divided to the middle, or just beyond into somewhat unequal lobes, ovate to obovate, obtuse or rounded and sometimes irregularly denticulate at the apex, glandular-ciliolate, farinose or efarinose outside. Corolla bright violet, more or less powdered with snow-white meal outside, 8–12 mm. long; tube hardly longer than the calyx, cylindrical for the lower 3–4 mm., gradually widening into the subglobose bell-shaped limb: lobes concave, broadly elliptic to almost round, 1·5–3 mm. long, entire or slightly emarginate. The species is monomorphic: stamens inserted near the mouth of the tube and style projecting slightly above them. Capsule oblong, about 5 mm. long, splitting into 5 linear-lanceolate valves.

In the Edinburgh Herbarium are the following:—

ASSAM-BURMA-TIBET FRONTIER. Seinghku Wang (*Ward*, 6975—*cotype*); Delei valley (W. 8252, 8406).

S.E. TIBET. (*Ludlow, Sherriff and Taylor*, 4724).

P. deflexa Duthie in Gard. Chron., Ser. 3, xxxix, 229 (1906); Jardin, xxii, 185 (1908); Dunn in Notes Roy. Bot. Gard. Edin., v, 62 (1911); Balf. f. in Journ. Roy. Hort. Soc. London, xxxix, 132, 138, 151, 152, fig. 53 (1913); McLaren, *ibid.*, liv, 66 (1929); W. W. Sm. et Forrest, *ibid.*, liv, 35, 36 (1929), and in Notes Roy. Bot. Gard. Edin., xvi, 29 (1928). *P. conica* Balf. f. et Forrest in Notes Roy. Bot. Gard. Edin., ix, 157 (1916); Gard. Chron., Ser. 3, lix, 247 (1916); Garden, lxxx, 276 (1916); Journ. Roy. Hort. Soc. London, xlii, Proc. cix (1917); Hand.-Mzt., *ibid.*, liv, 58 (1929). *P. muscarioides* Hemsl. subsp. *conica* (Balf. f. et Forrest) W. W. Sm. et Forrest in *ibid.*, liv, 36 (1929), and in Notes Roy. Bot. Gard. Edin., xvi, 29 (1928); Gould in Journ. Roy. Hort. Soc. London, liv, 73 (1929); Adamson, *ibid.*, liv, 81 (1929). *P. Viali* Pax in Engler's Pflanzenr. Primulaceae, 92, fig. 27 C (1905)—pro parte, non Franchet.

This beautiful species was discovered by Wilson in Western China at altitudes of 3300–4300 m., and the type specimen, *Wilson* 4035, is in the Kew Herbarium. In July 1914 Forrest collected in Yunnan on the Chungtien plateau at an altitude of 3700 m. a plant which Balfour and he described as a new species, under the name of *P. conica*. They associated it with *P. gracilenta* Dunn chiefly because the scapes of the two plants were markedly hairy. The difference in the structure of the corolla of these two species led Smith and Forrest to seek a closer relationship for Forrest's plant, and in their revision of the sections of the genus in 1928 (*l.c.*) *P. conica* is ranked as a subspecies of *P. muscarioides* Hemsl., from which it can be separated by the hairy scape. Scattered hairs can occasionally be found on the scapes of most of the species in the section, but only on the scapes of *P. gracilenta*, *P. euchaites*, *P. deflexa*, and *P. conica* are they numerous and constantly present. The acute corolla-lobes serve to distinguish *P. gracilenta*; *P. euchaites* is readily separable by the entire or minutely denticulate leaves, by the meagre inflorescence and by the black hairs on the bracts and calyx. But the geographical areas for *P. conica* and *P. deflexa* are now known to be continuous, and as no character of any moment has been found to keep them apart, *P. conica* is to be regarded as synonymous.

Leaves oblong to oblanceolate, up to 20 cm. long and 3 cm. broad, bright green and shining, rounded or obtuse or subacute at the apex, gradually tapering into the winged petiole 2–5 cm. long, irregularly crenate-dentate and ciliate at the margin, lightly covered above and below with white septate hairs especially on mid-rib and veins. Scape stout, hairy, efarinose, 30–60 cm. high, carrying a short spike or compact head. Flowers sessile, markedly deflexed, dark blue or rose-purple or white with a delicate blue eye, supported by ligulate, deflexed, ciliate bracts up to 10 mm. long. Calyx urceolate, 4–5 mm. long, glandular-viscid both within and without, divided into unequal, rotundate to ovate-rotundate, strongly ciliate lobes. Corolla tubular-infundibuliform, about 1·5 cm. long; lobes emarginate, subrotundate, 2–2·5 mm. long. In thrum-eyed flowers stamens, with anthers 1·5 mm. long, inserted 10 mm. from the base; style 2·5 mm. long.

The species is amply represented in the Edinburgh Herbarium by the following collections:—

YUNNAN. Chungtien plateau (*Forrest*, 12707—*type* of *P. conica*);

mountains N.E. of Chungtien (F. 16635); on the Doker-la, Mekong-Salwin divide (F. 20764); Haba Shan (F. 30212). On mountains west of Hsiao, Chungtien (*Rock*, 24636).

S.W. SZECHUAN. Mountains around Muli (*Forrest*, 20474, 21416, 30274); Yingbu Shan (F. 30260, 30266). Mountains of Kulu (*Rock*, 23938, 24465); Mount Mitzugo, west of Muli Gomba (R. 16584, 16190); Mount Konka, Risonquemba, Konkaling (R. 16295, 16400); Djesi-La and Djesi-Longba, south of Tatsienlu (R. 17540); North of Chiu-Lung-Hsien, south-west of Tatsienlu (R. 17762); mountains of Baurong and east of the Yalung River (R. 17789); on Kanshu Shan, on trail to Leirong (R. 24061, 24476); without precise locality (R. 23687); woodlands around Tatsienlu (*Wilson*, 1312); (*Cunningham*, 582); (*Harry Smith*, 10607); Sungpan-Hsien (*Fang*, 4435).

P. deflexa was brought into cultivation by Messrs. J. Veitch & Sons in 1906 and has from time to time flowered in British gardens either under its true name or as *P. conica*. It received an Award of Merit from the Royal Horticultural Society when exhibited by Messrs. Wallace of Colchester in May 1916.

P. euchaites W. W. Sm. in Notes Roy. Bot. Gard. Edin., xv, 301 (1927); W. W. Sm. et Forrest, *ibid.*, xvi, 29 (1928), and in Journ. Roy. Hort. Soc. London, liv, 36 (1929).

This species is known only from one small collection of Ward at Seinghku Wang on the Burma-Tibet Frontier in 1926. He found it hanging down from the grassy ledges of limestone cliffs at an altitude of 4300 m. It is a plant clearly distinguished from the other members of the section by the presence of septate black hairs on the bracts and on the calyx. Additional diagnostic marks are the very hairy scape, the few-flowered capitulum and the lack of any farina except for one or two specks to be seen only under a lens on the bracts and calyx. Its general habit is that of the slenderer members of the section such as *P. gracilenta* and *P. aerinantha*. It comes like *P. concholoba* from an area between the East Himalaya and S.W. China and is not closely akin to the Muscarioides of either region.

Leaves about 6 cm. long and 1 cm. broad, with the petiole and the lamina equal in length; the latter narrowly oval, rounded at the apex, cuneate at the base, subentire at the margin, covered both above and below with white articulated hairs more numerous on the upper surface. Scape only 8 cm. high, slender, hairy, carrying a head of 5–6 flowers; bracts small, linear to ovate, covered with short black hairs. Calyx similarly hairy, about 4 mm. deep, divided into ovate to triangular lobes, 2–2·5 mm. long, 1·5 mm. broad, acute at the apex, glandular-ciliate. Corolla violet, fading to white towards the centre, efarinose, about 1·5 cm. long, with the narrow tubular portion 8 mm. long, and with the limb divided into obcordate, emarginate lobes, 4 mm. long, 3·5 mm. broad. In long-styled flowers stamens inserted 4 mm. from the base of the tube; style 8–9 mm. long.

In the Edinburgh Herbarium this little-known species is represented by:

BURMA-TIBET FRONTIER. Seinghku Wang (*Ward*, 7052).

P. Giraldiana Pax in Engler's Pflanzenr. Primulaceae, 92, fig. 27, A and B (1905); Dunn in Notes Roy. Bot. Gard. Edin., v, 61, 62 (1911); Balf. f. in Journ. Roy. Hort. Soc. London, xxxix, 134, 135, 151 (1913); W. W. Sm. et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 29 (1928), and in Journ. Roy. Hort. Soc. London, liv, 36 (1929).

Nothing is known of this rare species beyond the collections of Giraldi who found it on a range of mountains called the Tai-pa-Shan in the province of Shensi. It is therefore the most northern representative of the section, closely followed in that respect by *P. aerinantha*. The type, *Giraldi* 4696, is in the Berlin Herbarium and when on loan to Edinburgh some years ago was examined by one of the present authors, notes and photographs being taken in supplement of the original description. *P. Giraldiana*, as described and figured by Pax, bears a very strong resemblance to the Forrestian plant published later by Hemsley as *P. muscarioides*. At the Primula Conference in 1913 Balfour (*l.c.*), relying on the figure and without material of the Shensi plant, considered the two to be conspecific. To this opinion he did not adhere afterwards when *P. muscarioides* was more fully known. Be it noted, however, that the plants illustrated in fig. 54 of Balfour's paper, under the name of *P. Giraldiana*, are *P. muscarioides*. The former was never collected by Forrest and has not been in cultivation. The affinity of the species is more with *P. aerinantha* and *P. gracilenta* where the inflorescence tends to be capitular rather than spicate with a corresponding reduction in the number of the component flowers.

Leaves narrowly oblong, membranous, 5–6 cm. long, 1–2 cm. broad, obtuse at the apex, gradually tapering into the subequal winged petiole, irregularly crenate-dentate at the margin, pilose above and below especially on the veins. Scape 20–30 cm. high, glabrous, towards the apex slightly farinose, carrying a globose or subcylindrical head of 10 or more sessile reflexed flowers. Calyx campanulate, about 4 mm. long, faintly farinose, lobed at least to the middle; lobes ovate, acute, and ciliolate. Corolla bluish-violet; tube 3–4 times the length of the calyx; limb nearly 10 mm. in diameter, farinose within, with lobes broadly ovate and entire.

P. Giraldiana is not represented in the Edinburgh Herbarium save by a series of photographs of the type.

P. gracilenta Dunn in Notes Roy. Bot. Gard. Edin., v, 62, 64 (1911); Balf. f. in Journ. Roy. Hort. Soc. London, xxxix, 134, 138, 152 (1913); Gard. Chron., Ser. 3, lvii, 207 (1915); W. W. Sm. et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 29 (1928), and in Journ. Roy. Hort. Soc. London, liv, 36 (1929).

P. gracilenta and *P. Viali* Franch. differ from all other members of the section in having acute corolla lobes. *P. gracilenta* is easily distinguished from *P. Viali* by the shorter hairy scape which carries either a compact head or a very short spike of flowers instead of an elongate spike surmounted by a crimson cone of bracts. Although associated with *P. Viali* in respect to the acute corolla-lobes, the species has nearer kinship with *P. aerinantha* and *P. Giraldiana* possessing subcapitate inflorescences. This species was collected in 1889 by Pratt in Western Szechuan and on the Tibetan frontier at altitudes of from 3000–4500 m., and the type specimen, *Pratt* 252 (in part), is in the Kew Herbarium. Much later it was found again by Forrest, Ward, and Rock growing on ledges of limestone cliffs and in moist open meadows.

Leaves elliptic to oblong-elliptic, up to 15 cm. long and 4 cm. broad, rounded at the apex, gradually tapering into the slightly winged hairy petiole, irregularly dentate at the margin, hairy on both surfaces especially on the midrib, the hairs being white and septate. Scape 10–20 cm. high, hairy, efarinose, carrying a compact head or short close spike of 7–15 fragrant flowers. Calyx cup-shaped, 3–4 mm. long, divided to the middle into ovate acute long-ciliate teeth. Corolla deep bluish-purple, about 12 mm. long, efarinose, with cylindrical tube 8 mm. long and limb cut into ovate-oblong lobes, 4 mm. long, up to 2 mm. broad, acute or rarely obtuse at the apex where there is often an apiculus. In pin-eyed flowers stamens inserted about 4 mm. from the base of the corolla-tube; style 6 mm. long.

Representing *P. gracilenta* in the Edinburgh Herbarium are the following collections:—

YUNNAN. N.W. flank of the Lichiang Range (*Forrest*, 10410, 11352); mountains N.E. of the Yangtze bend (F. 10692); mountains of the Chungtien plateau (F. 12570); without precise locality (F. 28529).

S.W. SZECHUAN. Mountains east of Yung-ning (*Forrest*, 21233); east of Yung-ling Lake (F. 30251); Yung-ling (F. 30268). Yangtze range, W. of Yung-ning (*Ward*, 5248). Mount Konka, Risonquemba, Konkaling (*Rock*, 16308).

Seeds of *Forrest* 11352 germinated and plants were flowered in Edinburgh in March 1915. The species was soon lost to cultivation, but was reintroduced in 1932 by the Marquess of Headfort who raised it from seeds of *Forrest* 28529.

P. hyacinthina W. W. Sm. in Notes Roy. Bot. Gard. Edin., xix, 170 (1936).

Discovered by Ward in 1935, in the valley of the Loro Chu in S.E. Tibet, at an altitude of 4300 m., this species, with a strong scent of hyacinth, is the only member of the section to have the lower surface of the leaves covered with white farina. In 1936–38 the plant was again found in S.E. Tibet by Ludlow, Sherriff and Taylor, on stony hillsides and at the base of overhanging cliffs, at altitudes of 4200–5300 m. Some of the specimens evidently came from a drier or less kindly area for they are dwarfed, with leaves not exceeding 2·5 cm. in length and with much fewer flowers to the scape. They represent the same species and moreover show, except for the dense farina on the under-surface of the leaves, a marked approximation to *P. bellidifolia*. The affinity of the species is closer to the latter than to *P. muscarioides* with which it was first compared. In cultivation some of the leaves of the same plant are occasionally efarinose or nearly so. It may well be that *P. hyacinthina* is but a strongly farinose variety of *P. bellidifolia*.

Leaves 16–18 cm. long, 2 2·5 cm. broad, oblanceolate to oblong, obtuse or subrotund at the apex, gradually attenuate into the winged hairy petiole, irregularly denticulate at the margin, well covered with white or pale tawny articulated hairs above, markedly pilose on mid-rib and lateral veins below. Scape 20 45 cm. high, devoid of hairs, conspicuously farinose or efarinose except immediately at the apex. Flowers numerous, deflexed, violet, arranged in a compact spike 2·5 cm. long, or in a capitulum 2–2·5 cm. in diameter, supported by green to blackish-purple bracts, farinose within, glandular-ciliolate at the margin. Calyx 5–7 mm. deep, divided into oblong lobes, 4 mm. long, 3 mm. broad, rounded and then suddenly acute at the apex, markedly glandular-ciliate. Corolla about 17 mm. long, with a narrow tube some 10 mm. long; limb cut into obcordate lobes 4 mm. long and 5 mm. broad. Stamens in pin-eyed flowers inserted 3·5 4 mm. above the base of the corolla-tube; style 8 mm. long. In short-styled flowers stamens inserted 8 mm. above the base of the corolla-tube; style 3·5 mm. long.

The type specimen is in the British Museum Herbarium and the species is represented in Edinburgh by the following:—

S.E. Tibet. Trön, Valley of the Loro Chu (*Ward*, 11800—*cotype*); Tsari, on the Shagam La (*Ludlow and Sherriff*, 2185); on the Le La, Chayul-Charme (*L. and S.*, 2294); Tse La (*Ludlow, Sherriff and Taylor*, 5635); Paka Phu Chu (*L. S. and T.*, 5888); also *L. S. and T.*, 5034.

Plants grown from the seed of *Ludlow and Sherriff* 2294 were brought to the flowering stage in Edinburgh in July and August 1939 and no doubt in other gardens.

Primula inopinata Fletcher in Journ. Linn. Soc., lii, ined. (1942).

In October 1937 Mr. T. T. Yü collected at Chungtien in Yunnan at 3000 m. fruiting specimens (under number 13861) of *P. aromatica* W. W. Sm. et Forrest, an interesting species of the Malvacea section which Forrest found on the Tali Range and which in the dried condition has the fragility associated with dried plants of *Impatiens*. Seeds under this number sent to Edinburgh germinated in 1939 and plants were brought to flowering stage in 1940. Possibly owing to some mistake in seed-collecting the plants bore no relationship to *P. aromatica* nor to any other species in its section, but represented this most unusual new species of the section Muscarioides. Though in its foliage *P. inopinata* is strongly reminiscent of the Muscarioides and especially of *P. pinnatifida* Franch., in the character of its inflorescence it is quite distinct in the section. The flowers are not arranged in a close spike or capitulum and in the flower-bud the posterior and postero-lateral calycine lobes do not cover the rest of the flower. Consequently there is no overlapping of segments to give the surface of the young inflorescence an imbricate appearance as of a tiled roof. On the contrary the flowers are arranged in a loose raceme and thus the species stands in the same relationship to the section Muscarioides as do *P. spicata* Franch. and *P. siamensis* Craib in the section Soldanelloideae. Noteworthy also are: the corolla-limb is larger in proportion to the tube than is usual in Muscarioides, the corolla-lobes are somewhat deeply cleft with a blunt projection at the base of the sinus, the calyx is irregular with the posterior lobes larger as in Muscarioides, and the scape and calyx with numerous capitate-glandular hairs show no obvious farina but suggest the potentiality for it.

P. inopinata is an aromatic glandular-hairy efarinose plant up to 18 cm. tall. Leaves, arranged in a dense tuft, oblong to oblong-obovate, up to 6 cm. long and 2 cm. broad, obtuse at the apex, tapering into the very broad but short winged petiole, lobulate and irregularly dentate at the margin, pubescent above and below with both simple and septate hairs, with the nerves sunk on the upper surface and prominent on the lower. Scape sturdy and glandular-pubescent, up to 18 cm. tall, carrying a short raceme of flowers smelling strongly of hyacinth; bracts linear-oblong to oblanceolate, sometimes slightly dentate, up to 5 mm. long; pedicels 2 mm. long. Calyx marked with red striae, tubular-campanulate, glandular, 5 mm. long, divided to below the middle into narrow obovate unequal lobes, rounded and slightly incurved at the apex. Corolla deep bluish-violet except for the tube pale blue streaked with violet, the sinus between the lobes being white; tube narrow and cylindrical, 10–12 mm. long, somewhat curved; limb patent, 1·5 cm. in diameter; lobes obcordate, 7 mm. long, 5 mm. broad, emarginate for a third, conspicuously mucronulate between the lobules and occasionally rather unequal. In pin-eyed flowers style almost as long as the corolla tube; stamens inserted 4 mm. from the base of the tube.

The only herbarium specimen is:

YUNNAN. Chiren, Chungtien. (*Type*—cult. plant from seed of *Yü*, 13861.)

There are also photographs of the living plant with enlargements to show floral details.

P. Mairei Lévl. in Le Monde des Plantes, xvii, Nos. 92–93, 2 (1915).
P. cephalantha Balf. f. in Notes Roy. Bot. Gard. Edin., ix, 10 (1915); W. W. Sm. et Forrest, *ibid.*, xvi, 29 (1928), and in Journ. Roy. Hort. Soc. London, liv, 36 (1929).

The only collector of this species appears to be E. E. Maire who made two gatherings of it in 1912—one in the alpine meadows of Io-Chan at an altitude of 3300 m. and the other on the high plateau of Ié-ma-tchouan at 3200 m. Both these places are in N.E. Yunnan. A portion of the first material was sent to Léveillé who published a description of the plant early in 1915. The remaining specimens were purchased from Maire by Edinburgh in 1914 and Balfour's diagnosis, issued also in 1915, is a few months later than that of Léveillé. Undoubtedly the closest ally is *P. pinnatifida* which is a plant of the mountain ranges of Western Yunnan. The form of the leaf is more or less the same in the two species, but *P. Mairei* has much more hairy foliage with a matt surface and not shining as in its ally. Other criteria are not very convincing—the posterior lobe of the calyx is not denticulate, the lobes of the corolla are not imbricate and not entire, the bracts and calyx in the late flowering and fruiting stage become coated with yellow farina. Only further material from Eastern Yunnan can determine whether *P. Mairei* is to be regarded as a valid species or only a variety of its ally.

Leaves oblong to sublanceolate, up to 10 cm. long and 2 cm. broad, obtuse at the apex, tapering into the winged petiole 1–3 cm. long, incised-lobulate to coarsely dentate at the margin, softly hairy above and below. Scape up to 25 cm. tall, yellow-farinose especially towards the apex, carrying a subspicate head of deflexed flowers; bracts slightly farinose, minutely ciliolate, up to 7 mm. long. Calyx cup-shaped, yellow-farinose, about 4 mm. long, divided to the middle into mucronulate unequal lobes, the posterior one not denticulate. Corolla purple and very faintly farinose without; tube about 8 mm. long; lobes oblong to subrectangular, about 2·5 mm. long, emarginate. In thrum-eyed flowers stamens inserted at the mouth of the corolla-tube; style shorter than calyx.

The species is represented in Edinburgh by:

N.E. YUNNAN. Io-Chan (*Maire*, s.n.—*type*); Ié-ma-tchouan (M. s.n.—*type* of *P. cephalantha*).

P. muscarioides Hemsl. in Kew Bull., 319 (1907); Bot. Mag., t. 8168 (1907); Dunn in Notes Roy. Bot. Gard. Edin., v, 61, 62 (1911); W. W. Sm. et Forrest, *ibid.*, xvi, 29 (1928), and in Journ. Roy. Hort. Soc. London, liv, 35, 36 (1929); Hand.-Mzt., *ibid.*, liv, 61 (1929); Gould, *ibid.*, liv, 73 (1929). *P. tsarongensis* Balf. f. et Forrest in Notes Roy. Bot. Gard. Edin., xii, 22 (1920). *P. Giraldiana* Balf. f. in Journ. Roy. Hort. Soc. London, xxxix, 134, 135, 151, 153, fig. 54 (1913)—non Pax.

This fine species inhabiting moist meadows was gathered by Forrest in S.E. Tibet in 1904. Seeds were collected in 1905 and sent to Bees Ltd. of Cheshire. Of the plants which resulted, one was forwarded in 1907 to Kew for identification and was the basis of Hemsley's diagnosis and also of the figure and text in the Botanical

Magazine of the same year. It was compared and quite correctly with *P. cernua*, *P. deflexa*, and *P. pinnatifida*, and also with *Wilson* 4036 which we now know as *P. Watsoni*. As noted under *P. Giraldiana*, Balfour (*l.c.*) relying on Pax's description and figure believed it to be that species but later accepted it as distinct. From these allies *P. muscarioides* can be readily distinguished, except from *P. deflexa*, closely akin and very similar in habit. The territory of the two species is in part common to both. *P. deflexa* extends more to the north, has a more or less hairy scape and is efarinose. *P. tsarongensis*, represented by a single gathering, comes from an area in which *P. muscarioides* is also found, is robust and somewhat more farinose but has no claim to specific rank.

Leaves obovate-spathulate or elliptic to oblong, 10–20 cm. long, 3–5 cm. broad, rounded at the apex, gradually tapering into the winged petiole, crenate-dentate at the margin, slightly hairy and shining above, almost glabrous below except for a few hairs along the fleshy mid-rib. Scape up to 40 cm. tall, glabrous but for occasional scattered hairs, efarinose except at apex. Flowers fragrant, deep purplish-blue, arranged in a compact head or short spike, conspicuously reflexed, supported by linear bracts. Calyx campanulate, 5 mm. long, usually almost efarinose, cut into ovate-oblong non-ciliate unequal lobes, the uppermost broader and 2–3-toothed. Corolla about 12 mm. long; tube 8 mm. long; lobes broadly elliptic, 2 mm. long, 2 mm. broad, truncate or emarginate. In thrum-eyed flowers stamens, with anthers 1·5 mm. long, inserted 7–8 mm. above the base of the corolla-tube and style about 2 mm. long.

The cultivated type is in the Kew Herbarium and in Edinburgh there are the following collections:—

YUNNAN. Yangtze-Mekong divide, Kari Pass (*Forrest*, 313); Bei Ma Shan (F. 13293); Chienchuan-Mekong divide (F. 23402); without precise locality (F. 17242, 30273); Chinsa Shan (F. 30234); Upper Salwin, mountains west of Champutong (*Rock*, 22533); Mount Kaakerpo (R. 22991, 23238); Mekong-Salwin divide (*Ward*, 92C); without locality (*Monbeig*, 180).

SZECHUAN. Mountains around Muli (*Forrest*, 16325); Dongrergo (*Harry Smith*, 3842); Mount Konka, Risonquemba, Konkaling (*Rock*, 16323).

S.E. TIBET. Mekong-Salwin divide, west of Tsekou (*Forrest*, 306, 13425, 14159); Salwin–Kiu-Chiang divide (F. 18987, 19084); Tsarong (F. 14805—*type* of *P. tsarongensis*); Kenichunpo (*Rock*, 21953); Tsekou (*Soulié*, 1347—probably first finding about 1895).

In the Herbarium there are also a few collections of Forrest in fruit, from the Chienchuan-Mekong divide (F. 17008, 22250, 22375, 22569) with leaves more cut than in the typical plant. The degree of division of the leaves approaches that of *P. pinnatifida* Franch., though Forrest's plants are far too robust for that species. He himself considered them but cut-leaved forms of *P. muscarioides*. Somewhat aberrant also is *Rock* 16323 where the under surface of the leaves has a light coating of farina—a rare occurrence in the section.

The species is still in cultivation. A white-flowered sport has been recorded.

P. pinnatifida Franch. in Bull. Soc. Bot. Fr., xxxii, 271 (1885); Pax in Engler's Bot. Jahrb., x, 187 (1889); Forbes et Hemsl. in Journ. Linn. Soc. Bot., xxvi, 41 (1889); Pax in Engler's Pflanzenr. Primulaceae, 66 (1905); Balf. f. in Journ. Roy. Hort. Soc. London, xxxix, 136, 151, 152, fig. 56 (1913); Forrest, *ibid.*, xli, 207, fig. 78 (1915); Ward, *ibid.*, xlviii, 205 (1923); W. W. Sm. et Forrest, *ibid.*, liv, 35, 36 (1929); Hand.-Mzt., *ibid.*, liv, 59 (1929); Adamson, *ibid.*, liv, 81 (1929); W. W. Sm. et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 29 (1928).

Delavay discovered this species on the Lichiang Range in 1884, and the type specimen, *Delavay* 9, is in the Paris Herbarium. Apparently nothing more was heard of the plant until 1906 when it was again found by Forrest on a visit to the Lichiang Range. In subsequent years he often collected it on nearly all the main ranges in Western Yunnan and extended its distribution into Szechuan. It is closely related to *P. muscarioides*. Usually the deeper cutting of the leaves is enough to distinguish *P. pinnatifida*, on the whole a dwarfer plant. Additional characters are the more farinose scape of *P. pinnatifida* (that of *P. muscarioides* if at all mealy is so only at the very apex) and the wider corolla-limb with more patent and entire lobes (those of *P. muscarioides* being usually emarginate). In their typical condition the two species can be readily discriminated, but transitions between them may occur. *P. pinnatifida* is found more regularly on such areas as the limestone of the Lichiang Range, while *P. muscarioides* is seen more to the north-west of Yunnan in a wetter region. As noted under *P. muscarioides*, specimens are sometimes secured too robust for *P. pinnatifida* and more cut in the leaf than is consistent with *P. muscarioides*, and these appear to be of intermediate character. *P. pinnatifida* varies much more than its ally in habit and in the degree of cutting of the leaf. Forrest found dwarf forms about 2·5 cm. high on the Lichiang Range in ultra-alpine situations. These have attached to them the name var. *nana* Balf. f. mss. and are represented by *Forrest* 6110. More aberrant is another form or variety—var. *sectilis* Balf. f. mss.—occurring in stony alpine pasture in the N.W. of the Lichiang with leaves doubly pinnatifid and the ultimate segments narrow-oblong –*Forrest* 10407, 12606. Another close ally is *P. apoclita* of the same size and general habit, but much more hairy and with leaves only crenate-serrate and not deeply cut.

Leaves ovate, oblong or spathulate, 2–10 cm. long, 1–2 cm. broad, rounded at the apex, gradually tapering into the subequal petiole, incised-lobulate to very coarsely dentate at the margin, lightly covered with septate hairs above, almost glabrous below except for long white hairs along the mid-rib. Scape usually 5 20 cm. tall, sometimes in fruit exceeding 40 cm., invariably farinose in the upper half, carrying a compact head or short spike of fragrant deep blue slightly farinose flowers supported by lanceolate acuminate bracts. Calyx shortly campanulate, sometimes slightly farinose, 4–5 mm. long, divided into rather irregular ovate to elliptic lobes, 2·5 -3·5 mm. long, obtuse or in the posterior lobe notched at the apex, ciliolate at the margin. Corolla about 15 mm. long; tube 8 mm. long, gradually widening into the limb; lobes ovate to subrotund, 4 mm. long and broad, rounded and not emarginate at the apex. In pin-eyed flowers style 7 mm. long; stamens inserted about 3·5 mm. above the base of the corolla-tube.

The species is abundantly represented in Edinburgh by these collections:—

YUNNAN. Lichiang Range (*Forrest*, 2398, 5953, 6110, 10286, 10407, 10682, 15229, 28217, 28220, 30318); Chien-chuan Mekong divide (F. 21474, 21983, 22000, 23404); mountains of the Chungtien plateau (F. 12606, 12645); without precise locality (F. 28758, 28856, 29216, 30291). Lichiang, Mount Satseto (*Rock*, 24893); Yun-lu shan, S.W. of Lichiang (R. 25073, 25392); Kin-tzu shan, Labako (R. 25143); on Yu-lung shan (R. 25337).

S.W. SZECHUAN. Muli Mountains (*Forrest*, 16804); Mount Siga, N.E. of Kulu (*Rock*, 17862); Mount Mitzuga, west of Muli Gomba (R. 16533, 16538); mountains between the Litang and Yalung rivers (R. 16633, 16635); Mount Gibboh (R. 24186).

Introduced in 1908 by Bees Ltd. from Forrest's seeds, it remained in cultivation for over 20 years, but may now be lost.

P. Viali Delavay ex Franch. in Bull. Soc. philom. Paris, 8 Sér., iii, 148 (1891)—pro parte; Pax in Engler's Pflanzenr. Primulaceae, 92 (1905)—pro parte; Watt in Journ. Roy. Hort. Soc. London, xxix, 306 (1904), and *ibid.*, xxxix, 206 (1913); Balf. f., *ibid.*, xxxix, 138, 151, 152 (1913); Dunn in Notes Roy. Bot. Gard. Edin., v, 62, 64 (1911); W. W. Sm. et Forrest, *ibid.*, xvi, 29 (1928), and in Journ. Roy. Hort. Soc. London, liv, 35, 36 (1929); Hand.-Mzt., *ibid.*, liv, 56 (1929). *P. Littoniana* Forrest in Notes Roy. Bot. Gard. Edin., iv, 225, t. 33, 35, 36 (1908); Dunn, *ibid.*, v, 62, 63 (1911); Garden, lxxiii, 361 (1909); *ibid.*, lxxx, 27 (1916); Gard. Chron., Ser. 3, xlvi, 14, 15 (1909); Bot. Mag., 8341 (1910); Journ. Roy. Hort. Soc. London, xxxv, Proc. p. cxlviii, fig. 96 (1910); *ibid.*, xxxix, 156, fig. 55 (1913); *ibid.*, xli, 204, 205, fig. 76, 77 (1915); Oesterr. Gart.-Zeit., viii, 293 (1913); Tribune Hort., ix, t. 409 (1914); Farrer, English Rock Garden, ii, 152 (1919); W. W. Sm. et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 29 (1928), and in Journ. Roy. Hort. Soc. London, liv, 35, 36 (1929); Hand.-Mzt., *ibid.*, liv, 56 (1929); McLaren, *ibid.*, liv, 66 (1929); Gould, *ibid.*, liv, 72, 75, 76 (1929). *P. Littoniana* Forrest var. *robusta* Forrest in Notes Roy. Bot. Gard. Edin., xiv, 47 (1929).

This plant, well known in cultivation under the name of *P. Littoniana*, was one of the discoveries of Abbé Delavay in Yunnan. It is one of the most remarkable of the members of the genus, and to anyone who has seen it in cultivation so different from any other species that there should have been no doubt as to its identity. Its history, however, is much confused and must be examined in some detail. It is evident that Delavay, though he did not describe the plant, recognised that it was new for he attached the mss. name *P. Viali* Delav. before sending material of it to Paris. It was his custom to retain for reference a moiety of his specimens and some of these, particularly Primula, came at length into the hands of his colleague Père Vial who brought them to France. A year or two ago this small collection was secured by purchase and given to the Edinburgh herbarium. It contains one of the originals of this species and in Delavay's own handwriting the legend: "Primula Viali Delav. Fl. violettes, très élégantes. Marais de Kan-hay-tze, près du col de Hee-chan-men, (Lankong), a 2800 m. d'altit., le 9 août 1888; legi ipse. J. M. Delavay." No reference is made to the outstanding feature—the long crimson apex of the spike. Consequently when Franchet published the species in 1891, that acute botanist included in his description and citations a plant collected by Soulié near Tatsienlu which we now know as *P. Watsoni*—not dissimilar in the dried state. His diagnosis is expressed so as to be applicable to both. The confusion is amplified in the description and figure given in the Monograph of Pax (*l.c.*). The latter had to rely, apart from the statement of Franchet, solely on material collected by Pratt under No. 252. The Pratt specimens at Kew are referable in part to *P. Watsoni* and in part to *P. gracilenta*. What Pax had before him is not clear, but his description fits best with *P. Watsoni*. His figure 27C, given as *P. Viali*, is not that species nor is it *P. Watsoni*. Dunn (*l.c.*) considers it to be *P. deflexa*. It is certainly nearer to that species than to anything else and there is no geographical reason forbidding Pratt's No. 252 in other herbaria than Kew to contain *P. deflexa*. Consequently *P. Viali* in the Monograph is a chimaera involving four species. It is evident that Pax never had the real *P. Viali* to examine. When Forrest rediscovered the plant in 1906 and subsequent years, he had to rely on these perplexing records in his search for a name and found it strange that so conspicuous a member of the Yunnan flora should be undescribed. The evidence, however, appeared conclusive and Forrest gave the plant the name of *P. Littoniana* after Consul Litton, his friend and companion-explorer. To this later he added a variety *robusta* with spikes nearly a foot in length but otherwise not differing from the typical plant. As will be seen from the discussion under Bot. Mag., t. 8341, the relationship of *P. Littoniana* to *P. Viali* and other allied species was already in 1910 a problem of much uncertainty and continued to be so for many years. There is, however, no doubt as to the identity of Forrest's plant with *P. Viali*. This unique species shares the character of acute corolla-lobes with *P. gracilenta* alone in the section, but is not therefore markedly akin. In its foliage and inflorescence it is more comparable with *P. deflexa* and *P. Watsoni*, both of which are involved in its somewhat complex history.

Leaves broadly lanceolate to oblong, 20–30 cm. long, 4–7 cm. broad, rounded at the apex, tapering into the winged petiole, remotely denticulate to irregularly dentate at the margin, hairy on both surfaces especially on the mid-rib below. Scape stout, 30–60 cm. tall, quite glabrous, farinose towards the apex, carrying numerous flowers arranged in a dense spike 6–18 cm. long. Flowers fragrant, strongly reflexed, supported by linear bracts. Calyx in immature flowers bright crimson; when mature globose-campanulate, 4–5 mm. long, farinose at the base, deeply divided into ovate to ovate-lanceolate pink lobes. Corolla bluish-violet, about 13 mm.

long; tube about 7 mm. long; limb divided into ovate to elliptic acute lobes, 5 mm. long, 4 mm. broad. In thrum-eyed flowers stamens 2 mm. long, inserted 7 mm. above the base of the corolla; style at most 2 mm. long. Capsule globose enclosed by the calyx.

The type specimen is in the Paris Herbarium and in Edinburgh are the following:—

N.W. YUNNAN. Kan-hay-tze near Hee-chan-men, Lankong (*Delavay—cotype*); on low range between the east side of the Lichiang valley and the Yangtze (*Forrest*, 2655—*type* of *P. Littoniana*); eastern flank of the Lichiang Range (F. 6123, 6151, 10449, 28221, 28594, 30321); mountains N.E. of Chungtien (F. 16895); Yung-ling (F. 30249); Chienchuan-Mekong divide (F. 23130); without precise locality (F. 29171, 29213, 30299); Go-bo, east of Lichiang snow-range (*Rock*, 24907); Mount Satseto, on the Lichiang snow-range (R. 24906).

S.W. SZECHUAN. Muli Mountains (*Forrest*, 16832, 16988, 23246, 28450); mountains S.E. of Muli (F. 22204, 22179—*type* of *P. Littoniana* var. *robusta*); without precise locality (F. 22490); mountains between the Litang and Yalung rivers (*Rock*, 16617, 16665, 16668); mountains of Kulu, east of Muli Gomba (R. 16463, 17400, 18083, 18210); on Yu-lung Shan (R. 25360, 25361); Mount Siga, overlooking the Yu-lung (R. 23861, 24408); Mount Gibboh (R. 24175, 24580).

Introduced into cultivation on its rediscovery by Forrest, the species can be regarded as well established. In its native place it flowers in July and August—not in April as was stated in the first description by Franchet. It is slow to appear above ground in the spring and July is its usual month for the first flowering. In normal seasons seed is produced freely.

P. violacea W. W. Sm. et Ward in Notes Roy. Bot. Gard. Edin., xiv, 54 (1923); W. W. Sm. et Forrest, *ibid.*, xvi, 29 (1928), and in Journ. Roy. Hort. Soc. London, liv, 36 (1929).

This species was discovered by Ward in 1921 on the Litang-Yalung divide, at an altitude of 4000–4300 m. amongst boulders and scrub. It is quite distinct from any other member of the section Muscarioides in possessing scabrid-pubescent leaves, lacking the articulated hairs characteristic of the other species.

Leaves 3–7 cm. long, 1–1·5 cm. broad, oblanceolate to lanceolate, obtuse to rounded at the apex, gradually tapering into the slightly winged petiole, entire or obscurely denticulate or sometimes irregularly dentate at the margin, scabrid-pubescent both above and below. Scape rising to a height of 25 cm., glabrous, thinly covered with white farina just below the short spike of 10–15 deflexed flowers supported by linear-oblong white-farinose bracts. Calyx cup-shaped, 4–5 mm. deep, divided into ovate lobes 3 mm. long, 3 mm. broad, rounded or faintly emarginate at the apex, blackish-purple, sparingly farinose without, strongly farinose within and sparsely ciliolate at the margin. Corolla 17–18 mm. long, deep violet, strongly powdered within with white meal; tube 10–11 mm. long, gradually widening into the limb; lobes 2·5 mm. long, 2·5 mm. broad, emarginate at the apex. In thrum-eyed flowers stamens, with the anthers 2 mm. long, inserted 10–11 mm. above the base of the corolla; style 1·5 mm. long.

It is represented in Edinburgh by the following:—

S.W. SZECHUAN. On the Litang-Yalung divide (*Ward*, 4386—*type*); mountains of Kulu (*Rock*, 18032, 18033).

The species has not been in cultivation.

P. Watsoni Dunn in Notes Roy. Bot. Gard. Edin., v, 63 (1911); Balf. f. in Journ. Roy. Hort. Soc. London, xxxix, 139, 151, 152, fig. 57 (1913); W. W. Sm. et Forrest, *ibid.*, liv, 35, 36 (1929); Hand.-Mzt., *ibid.*, liv, 52 (1929); W. W. Sm. et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 29 (1928). *P. cyanantha* Balf. f. et Forrest in Notes Roy. Bot. Gard. Edin., xiii, 7 (1920); W. W. Sm. et Forrest, *ibid.*, xvi, 29 (1928), and in Journ. Roy. Hort. Soc. London, liv, 35, 36 (1929); Gould, *ibid.*, liv, 73 (1929). *P. Viali* Pax in Engler's Pflanzenr. Primulaceae, iv, 93 (1905)—pro parte, non Franchet.

Dunn based his description of this species upon three collections from the mountains around Tatsienlu in Western Szechuan—part of *Pratt* 252, *Soulié* 152, and *Wilson* 4036—but did not say which he regarded as the type. Dunn's scrutiny of these herbarium specimens coincided with his examination of a living plant sent to Kew from Edinburgh which had been raised from seed forwarded from the same area by Mr. C. M. Watson. This plant was taken into account in the diagnosis and the species was named after the collector of the seed. The region round Tatsienlu has been more fully traversed in recent years and the species of Muscarioides concerned are *P. deflexa* and *P. Watsoni*. The distribution of both is now known to extend farther south. A plant strongly resembling *P. Watsoni* was discovered by Forrest in 1917 in the province of Tsarong, S.E. Tibet, and was described later by Balfour and Forrest as *P. cyanantha*. The claim of *P. cyanantha* to specific rank was subsequently doubted, and by Smith and Forrest (*l.c.*) it was reduced in 1928 to a subspecies of *P. Watsoni*. Additional material of both serves to show that they are conspecific. The nearest ally of *P. Watsoni* is *P. deflexa* from which it is readily distinguished by the glabrous farinose scape, by the deep indigo-purple of the corolla and particularly by the unusual form of the corolla lobes.

Leaves very hairy, subsessile or shortly petioled, oblong-ovate to oblanceolate, up to 15 cm. long and 5 cm. broad, rounded or obtuse at the apex, tapering at the base, crenate-lobulate at the margin. Scape 15–30 cm. high, glabrous, yellow-farinose especially towards the apex, carrying a head or short spike of numerous deflexed flowers supported by linear-lanceolate bracts. Calyx broadly campanulate, farinose at the base, 3–5 mm. long, cut to slightly beyond the middle, the lobes being glandular-ciliolate. Corolla deep indigo-purple, 12-15 mm. long; tube 10 13 mm. long; limb more or less erect and not so patent as in allied species; lobes remarkably short, only 1·5–2 mm. long and broad, truncate or quite conspicuously bi-lobulate. In thrum-eyed flowers stamens inserted in the throat of the corolla; style 2·5–3 mm. long.

In the Edinburgh Herbarium there are the following collections:—

S.W. SZECHUAN. Tatsienlu (*Watson*, spec. cult.); (*Harry Smith*, 10715); Muli Mountains (*Forrest*, 16666).

S.E. TIBET. On Ka-gwr-pu, Mekong-Salwin divide (*Forrest*, 14366—*type* of *P. cyanantha*); Londre Pass (F. 19622); on the Ata Kang La, Nagong (*Ward*, 10586).

BURMA-TIBET FRONTIER. Seinghku Wang (*Ward*, 6981).

YUNNAN. Mountains around Atuntzu (*Forrest*, 14048); (*Ward*, 92).

Discovered as far back as 1889, the species owes its introduction into cultivation to Mr. Watson, as his seeds collected in 1908 gave flowering plants in 1911. It is still to be found in various gardens, in many cases under the name *P. cyanantha*.

A LICHENOLOGICAL EXCURSION TO THE WEST OF SCOTLAND.

By I. MACKENZIE LAMB, D.Sc. (With Pls. III–IV.)

(Read 18th June 1942.)

INTRODUCTION.

The distribution of lichens in the British Isles is still far from well known. Much has been done by the extensive collections and studies of such eminent nineteenth-century lichenologists as Mudd, Leighton, and Crombie, and, in our own time, Miss A. Lorrain Smith and Dr. W. Watson, but when it is desired to make a detailed survey of certain species in the British lichen flora one is confronted as a rule by a great scarcity of reliable distributional data. Particularly does this hold good of the more northern parts of the British Isles, and it is apparent that further collections made by trained lichenologists in the Highlands and Islands of Scotland are greatly needed and are likely to bring to light a quantity of extremely valuable phytogeographical information.

Having this in mind, my wife and I undertook a fortnight's excursion to Argyllshire in June 1940. Naturally one could not expect to obtain in so short a time more than a brief glimpse into the lichen flora of the region, but nevertheless the small collection of 118 determinable species which we were able to bring back proved to contain much that was of phytogeographical or taxonomic interest, including as it did three new records to the British lichen flora (*Lecanora subrugosa*, *Stereocaulon denudatum* var. *umbricolum*, and *Verrucaria denudata*), together with a number of species new to the county.

Argyllshire is in many respects a favourable region for lichenological investigation, on account of its relatively sparse population and its varied configuration of mountainous country furrowed by deep glens and lakes, combined with inlets of the sea running far inland, and bounded on its western side by an Atlantic coast line studded with numerous islands. Unfortunately I was unable to travel far and wide over the county, but, with the exception of a single day's excursion to the summit of Ben Cruachan, was obliged to collect only within a very limited area on the north-west shore of Loch Awe, the largest of Argyll's inland lakes, lying at an altitude of 118 feet (37 m.) above sea-level. Consequently my gatherings include none of the more maritime or marine species which would have added considerably to their number. One may regard the collection, however, as giving a fairly representative picture of the lichens most likely to be met with in the inland parts of the west of Scotland lying between 56 and 57 degrees north latitude.

The specimens are deposited in the herbarium of the British Museum (Natural History), and a set of duplicates, in so far as they were available, in the herbarium of the Royal Botanic Garden, Edinburgh.

Natural Conditions of the Area.

The climate of this part of the west of Scotland is mild and humid, as might be expected from its oceanic situation. Around Loch Awe the mean annual temperature averages 45° F. (7·2° C.), and is not subject to any very great seasonal variation, the mean for January being 39°-40° F. (3·9°-4·4° C.), and that for July 57°-58° F. (13·9°-14·4° C.). The annual rainfall in Argyll is greatest in the mountainous eastern part of the county, where it amounts to over 100 inches (2540 mm.), and least in the western coastal strip and adjoining islands, 40-60 inches (1016–1524 mm.). Loch Awe lies between these two extremes, receiving on the average between 60 and 80 inches (1524–2032 mm.) of rainfall in the year. The snows of winter are not heavy, and rarely lie for long except on the higher summits.

The geology of the Loch Awe district is varied, several types of rock being represented on or near its shores. At North Port Sonachan, where the greater part of the present collection was made, the outcrops from the side of the lake to some distance up the low surrounding hillsides consist of black and hornblende schists; farther south its shores are bordered by metamorphosed quartzitic strata, which are not, however, included within the area here investigated. Metamorphic limestone appears on the surface of the hillside near Kilchrenan, a village some half-hour's walk westwards from North Port Sonachan, at an altitude of about 500 feet (150 m.). Other types of rock, such as mica-schist, gneiss, and basalt, also occur within a short distance of Loch Awe. The mountain Ben Cruachan at the northern end of the lake is made up of pink granite, which is quarried at its north-western base, on the shore of Loch Etive. This richness in different geological formations is another factor which favours ecological diversity in the lichen flora of the region, the limestone in particular harbouring species for the most part peculiar to calcareous substrata (obligate calciphiles). 69 of the lichens gathered, or 57·5 per cent. of the whole, were found on rocks and stones (including field-walls), and 13, or 10·8 per cent., on soil or on bryophytes growing over soil.

The woodlands in the area visited are sparse, and chiefly restricted to the shores of the lake, the higher slopes consisting of moorland and hill-pastures. With the exception of some spruce plantations, the trees are mostly angiospermous (*Acer*, *Alnus*, *Betula*, *Corylus*, *Fraxinus*, and *Quercus*), but *Larix europaea* is also fairly abundant on the shores and low hills surrounding the lake. The trunks of such trees bear a rich lichen vegetation (fig. 1), 32 species, or 26·7 per cent. of my collection, being corticolous. 6 of the species gathered (5 per cent. of the whole) were seen on both rocks and trees.

History of Lichenological Investigation in Argyllshire.

Although Scottish lichens are mentioned as far back as 1684 by Sibbald in his "Scotia Illustrata," it is only very rarely that one finds precise records of localities in these early works. Lightfoot, in his "Flora Scotica" (1777), quotes a number of lichens from "the Highlands," but no Argyllshire locality is mentioned. J. Dickson, the author of the "Fasciculus Plantarum Cryptogamicarum Britanniae" (1785–1801), visited Scotland on two occasions, in 1778 and 1779, and must have collected in Argyllshire, for one of the mosses listed in the work mentioned is stated to have been found at Inverary. He does not, however, refer to any Argyllshire locality in connection with the lichens.

The first exact records known to me of the lichens of this county are contained in Smith and Sowerby's "English Botany" (1790–1814), in which six lichens are noted from Inverary, Ballachulish, and Ben Cruachan, all collected by W. J. Hooker during two excursions made by him from Glasgow in the early years of the nineteenth century, the first time with W. Borrer, the second with D. Turner. Some of these records are repeated by Hooker in his "Flora Scotica" (1821), with the addition of several others from various parts of the county, making 17 species in all. The same author adds one further species to the known Argyllshire lichen flora in his "Supplement to English Botany" (1831).

Intensive collections of lichens in this region were first made by Dugald Carmichael (1772–1827), who settled at Appin, in the north of the county, on the shores of Loch Linnhe, and devoted all his time to the investigation of the cryptogamic flora. He also joined W. J. Hooker on one occasion on an excursion to Mull and

Skye. Some of his records are incorporated in vol. v. of the latter's continuation of Smith's "English Flora" (1844).

I find no trace of any further lichenological activity in these parts until the visit of J. M. Crombie in 1865, and subsequently in 1876. He collected in several places, including the island of Lismore, which is made up of metamorphic limestone, and found there several rare and interesting species, one of which, *Pterygium lismorense* Cromb., is known from only two localities in Scotland. The data derived from the first of these visits were entered up by Crombie in his "Lichenes Britannici" (1870), and found their way, together with those of his second excursion, into Leighton's "Lichen-Flora of Great Britain," ed. 3 (1879).

Several excursions to Argyllshire were made in the 'seventies by the Glasgow bryologist and lichenologist James Stirton, and some of the lichens which he found there are enumerated in Grevillea (1874) and Scottish Naturalist (1877).

The Rev. Hugh Macmillan visited Glencroe, which lies in E. Argyllshire, near the Dumbartonshire border, in 1874, and collected a number of lichens. These records (27 species) were published by him in these Transactions (1875).

From that time onwards, as far as I am aware, no collections of importance were made in Argyllshire until 1929, when Dr. W. Watson spent a short time there. A number of lichens collected by him on Ben Doran and by Loch Tulla, in the north-eastern part of the county, have been recorded in his "Lichenological Notes," v–viii (1930–35).

I am indebted to Dr. Watson for a copy of his census catalogue of British lichens, mentioned by him in a recent paper in these Transactions (1935), but as yet unpublished. From this catalogue it is apparent that 434 species of lichen have been found in Argyllshire, and some further records published by him in the present number (1942) brings the total up to 440. In the present paper 25 species and 4 varieties are added to that number, and there is no doubt that further collections in the county will bring to light many more.

Description of the Collecting Forays.

Most of our lichens were gathered in the immediate vicinity of North Port Sonachan. Only on one occasion did I range farther afield to make the ascent of Ben Cruachan on the 12th of June. For this reason the collections may be divided into two series on the basis of altitude: the bulk of the species being from low elevations, 110–490 feet (35–150 m.) above sea-level, and thus contrasting sharply with the high altitude of the Ben Cruachan gatherings (3689 feet or 1125 m.). As will be seen in the following section, this altitudinal difference is very distinctly reflected in the phytogeographical composition of the lichen flora.

By North Port Sonachan, from the 4th–11th and 15th–16th June, attention was first paid to the lichens growing by the roadside. This road is bordered by pasture fields, spruce plantations, and deciduous woods. On a stone gatepost was noted a sociation of *Parmelia fuliginosa*, *Placopsis gelida*, *Lecidea tumida*, and the moss *Rhacomitrium sudeticum* B. & S., all of them, however, in the sterile condition. At the margin of a wood the trunk of a *Fraxinus* tree was rendered conspicuous by its dense coat of lichen vegetation (fig. 1), the following species being represented: *Lecanora chlarona*, *Lobaria laetevirens*, *L. pulmonaria*, *Parmelia fuliginosa* v. *laetevirens*, and *Parmeliella plumbea*. The fields are bounded by walls of loose schistose blocks, which form a favourable habitat for many lichens. On one such wall having a southern exposure I noted: *Cladonia coccifera*, *Lecanora intricata*, *Lecidea fuscoatra*, *L. leucophaea*, *L. macrocarpa*, *Ochrolechia tartarea*, *Parmelia omphalodes*, *P. physodes* (f. *vittatoides*), *P. saxatilis*, *Pertusaria corallina*, *Placopsis gelida*, *Rhizocarpon Oederi*, and *Sphaerophorus globosus*. On another wall somewhat higher on the hillside, two *Stereocaula*, *S. evolutum* and *S. pileatum*, were fairly abundant, the latter associated, as often seems to be the case elsewhere, with *Placopsis gelida*.

The shore of the lake yielded many interesting species, both on rocks and on trees. Owing to the exceptionally dry spring and summer, the water had receded and left a wide strip of stony shore (fig. 2), on the boulders of which, normally within reach of the waves, but now far remote from the water's edge and exposed to prolonged desiccation, a zone was formed by the pale ochraceous thalli of *Aspicilia lacustris*. In some places *Catillaria chalybeia* was found forming a sociation with it; Degelius (1939) has noted the latter species at the sides of streams in Sweden, but unlike the *Aspicilia*, it is by no means confined exclusively to such moist habitats. Here and there in the same zone I observed sterile glaucous- or caesious-whitish thalli, and eventually found one with apothecia which showed it to be a *Lecidea*. Dr. Watson subsequently identified it as *L. mersata* Stirt.; it appears to be sufficiently distinct and allied to *L. albocoerulescens*, but restricted to lacustrine habitats.

On some parts of the shore a blackish zone of the moss *Cinclidotus* *fontinaloides* P. Beauv. is conspicuous just above the normal water level. Intermixed with this I found the semi-aquatic pyrenolichen *Staurothele fissa* in some abundance. *Dermatocarpon fluviatile* was also common at about the same level, on rocks and boulders, and in one place was accompanied by *D. miniatum* and *Rinodina confragosa.*

Farther up the side of the lake the stony foreshore merges into grassy *Alnus*-thickets interspersed with outcrops of schistose rock. Lines of debris indicate that in seasons of exceptional flood the waters of the lake may inundate these also. Now, however, they had been parched by the sun for many weeks. On the rocks I found *Lecanora atra*, *Lecidea* (*Psora*) *lurida* (on detritus in the clefts), *L.* (*Eulec.*) *speirea*, *Parmelia crinita* (on the higher parts, presumably out of reach of the floods), *Parmeliella plumbea*, *Parmularia muralis*, *Peltigera variolosa* (on the summits only), *Pertusaria lactea*, the rare *Polyblastia scotinospora*, *Rhizocarpon obscuratum*, *Sphaerophorus fragilis* (on the summits only), *Spilonema paradoxum*, *Stereocaulon evolutum* (on summits and sides), and *Verrucaria* cfr. *latebrosa*. The trunks of the *Alnus* trees harboured *Catillaria chalybeia* (usually a saxicolous species), *Cetraria glauca*, *Evernia prunastri*, *Lecanora crassula*, *L. subrugosa*, *Lecidea olivacea* f. *elaeochroma*, *Parmelia caperata*, *P. laevigata*, in one place the northern species (here somewhat of a rarity) *P. olivacea*, *P. pertusa*, *P. sulcata*, *P. trichotera*, *Physcia tenella*, *Ramalina farinacea*, *R. fraxinea*, and *Usnea*-sp.

Still farther in from the shore the wood acquires a mixed character, *Acer*, *Betula*, *Corylus*, *Fraxinus*, and *Quercus* gradually replacing the *Alnus*. On the bark of these trees I saw, in addition to several of those enumerated above, the following: *Arthonia*-sp., *Graphis scripta*, *Lobaria laetevirens*, *Nephroma lusitanicum*, *Ochrolechia parella* v. *tumidula*, *Pannaria rubiginosa*, *Parmeliella atlantica*, *Peltigera horizontalis* (near the ground), *Pertusaria amara*, *P. pertusa*, *P. Wulfenii*, *Pyrenula nitida*, *Ramalina calicaris* (growing among and over the *Ochrolechia parella* v. *tumidula*—one might speak of two distinct synusiae here), *Sticta limbata*, and *S. sylvatica*.

Gulls frequent certain parts of the shore and are partial to several large rocks upon which they congregate. On one such rock lying on the upper part of the foreshore there was an extensive development of the two nitrophilous lichens *Aspicilia caesiocinerea* and *Physcia caesia*; numerous excrementa containing fishbones being the source from which the nitrogen (presumably in the form of ammonia) was being derived.

Before leaving the margin of the lake, I examined the stones and

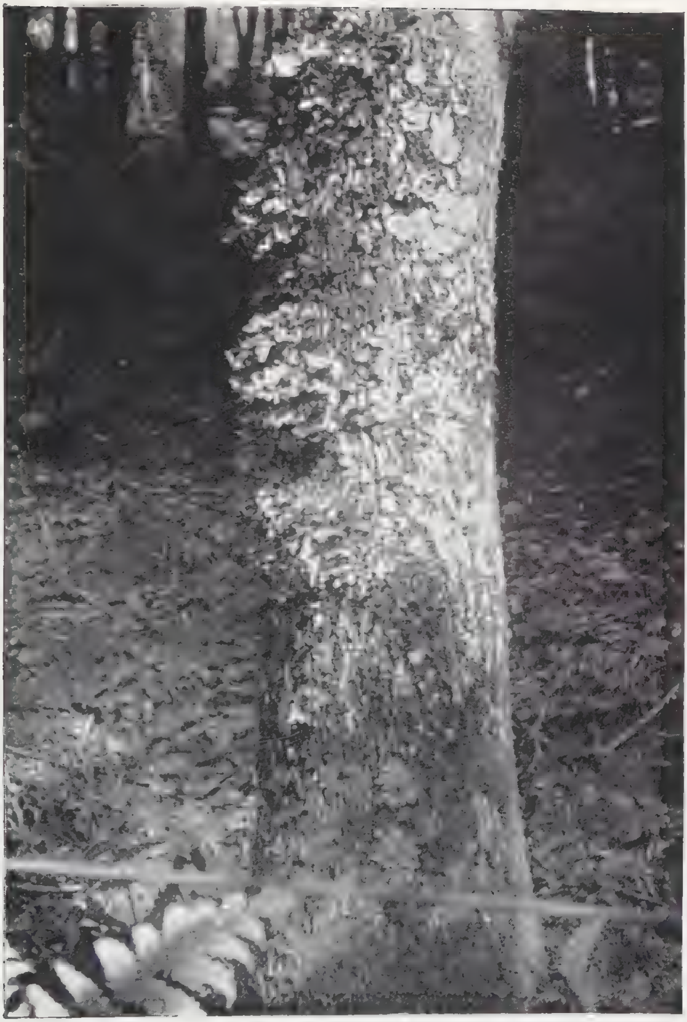

Photo. I. M. L., 8.VI.1940.

Fig. 1.—Lichen-covered trunk of *Fraxinus* at roadside, by North Port Sonachan.

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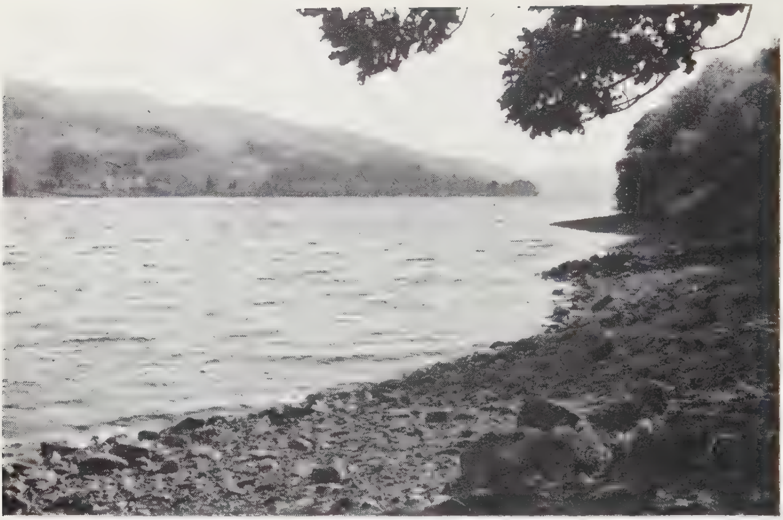

Photo. I. M. L., 5.VI.1940.

FIG. 2.—Shore of Loch Awe near North Port Sonachan.

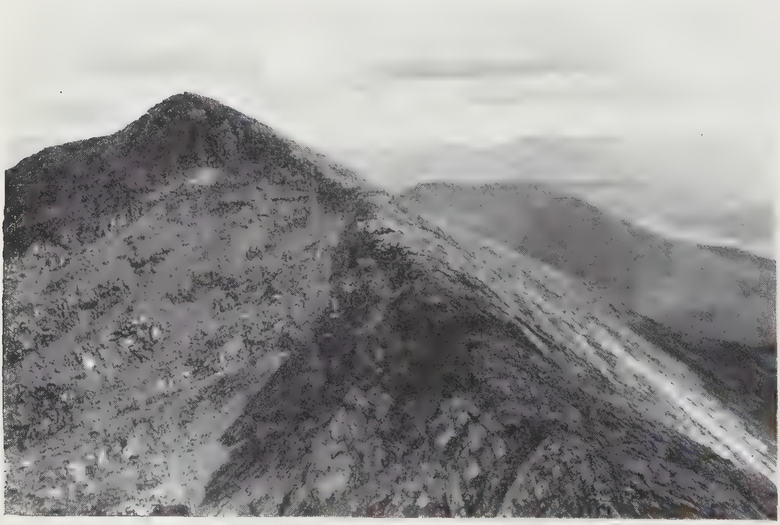

Photo. I. M. L., 12.VI.1940.

FIG. 3.—The summit of Ben Cruachan seen from the lower peak.

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pebbles lying in the bed of a small inflowing stream for the aquatic *Verrucariae* which are usually to be met with in such situations. Of these I found four: *V. aquatilis*, *V. denudata* (v. *Mougeotii*, new to the British Isles), *V. elaeomelaena*, and *V. laevata*. The last-named was above the surface of the water, but the others were entirely submerged.

On the hillside, at an altitude of some 350 feet (105 m.), a group of larch trees dominates a mound of artificial origin (Càrn Bàn). The trunks of these trees were found to be festooned with *Alectoria jubata* v. *prolixa*, accompanied by *Cetraria chlorophylla*, *Lecanora expallens*, *Parmelia furfuracea* (v. *olivetorina*), *P. physodes* (v. *labrosa*), and *Ramalina calicaris*. On some sloping slabs of schistose rock at their roots was a sociation of *Rhizocarpon* (*Catocarpon*) *Hochstetteri* and *Lecanora intricata*.

A moraine of small boulders in a field not far distant was inhabited by the following: *Lecidea lithophila*, *L. pelobotryon*, *L. tumida*, *Placopsis gelida* (f. *neglecta*), *Placynthium nigrum* (on a piece of calc sinter), and *Stereocaulon coralloides*.

The pasture fields themselves, being grazed by cows and sheep, were not very productive of lichens, but in places I saw *Cladonia impexa* (subsp. *laxiuscula*), *C. sylvatica*, and *C. uncialis*, and on the boulders emerging through the turf *Buellia spuria*, *Haematomma ventosum*, *Lecidea cyathoides*, *L. fuscoatra*, *L. lithophila* (f. *ochracea*), *L. macrocarpa*, and *Mycoblastus sanguinarius*.

Above the village of Kilchrenan, at an altitude of about 500 feet (150 m.), metamorphic limestone crops out on the hillside, and is quarried to a limited extent for burning in nearby kilns. These limestone rocks bear a lichen flora very different from that of the local schists. *Gyalecta jenensis*, *Lecidea fuscorubens* v. *ochracea*, *L. macrocarpa*, *Protoblastenia rupestris*, *Rhizocarpon concentricum*, *Thelidium papulare*, *Toninia cervina*, *Verrucaria coerulea*, and *V. macrostoma* were present on the rock itself, and *Baeomyces rufus* and *Solorina saccata* on the soil filling the interstices.

As mentioned above, the 12th of June was reserved for the ascent to the top of Ben Cruachan. I climbed the mountain up the gully called Allt Cruiniche. The ascent is laborious but nowhere difficult, except near the summit where innumerable huge blocks of granite are encountered (fig. 3). At the highest point of the second peak wide vistas of great beauty are opened on all sides; Loch Awe stretching like a ribbon to the south-west, Mull and Loch Linnhe to the west, the squat shape of Ben Nevis to the north, and the mountains of Perth to the east. I made an inventory of the lichens occurring on the topmost peak. The granite boulders were populated by *Alectoria* (*Subparmelia*) *pubescens*, *Cetraria fahlunensis* *Lecidea auriculata* v. *diducens*, *L. lactea*, *L. tumida*, *Parmelia alpicola*, *Pertusaria corallina*, extensive yellow patches of *Rhizocarpon* (*Catocarpon*) *oreites* (and probably also of *R.* (*Eurhizoc.*) *geographicum*), *Umbilicaria cylindrica* v. *fimbriata*, and *U. torrefacta*, together with the mosses *Andraea rupestris* Hedw. and *Rhacomitrium sudeticum* B. & S. Over the mosses on and between the boulders I noted *Bacidia melaena*, *Cetraria islandica*, *Cladonia bellidiflora*, *C. sylvatica*, *Coriscium viride*, *Lecidea caesioatra*, and *Stereocaulon denudatum* v. *umbricolum*. The descent was then made by the corry Coire a' Bhachaill down to the gully of Allt Brander, and thence back on to the Taynuilt road.

Phytogeographical Analysis of the Lichens Collected.

It will be of interest to analyse the distribution in Europe of the species composing the present collection. The following five phytogeographical types may be distinguished in the European lichen flora:—

1. Species more or less ubiquitous throughout Europe, ranging from northern Scandinavia to the south of Europe and there reaching or approaching the Mediterranean.

2. Species of southern distribution in Europe, their northern limit running across the Scandinavian peninsula.

3. Species of northern distribution in Europe, *i.e.* present in the Arctic and in Scandinavia (at any rate in the mountainous parts), in Central Europe occurring only at high altitudes.

4. Oceanic species, occurring most abundantly or sometimes exclusively along the western Atlantic coasts of Europe, and rare or absent in continental Europe. For further information concerning this distributional type, the work of Degelius (1935) should be consulted.

5. Species of eastern distribution in Europe.

Referring the lichens of the present collection to these categories, they can be classified with a greater or less degree of accuracy as follows:—

1. *Ubiquitous Group.*

Alectoria jubata v. *prolixa*, *Aspicilia caesiocinerea*,* *Bacidia melaena*, *Baeomyces rufus*, *Buellia spuria*, *Catillaria chalybeia*,

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* "A widely distributed species in Europe but avoiding its northernmost parts along the Arctic Ocean and probably also the southernmost parts round the Mediterranean" (H. Magnusson, in Kgl. Svensk. Vet.-Akad. Handl., xvii, no. 5, p. 70, 1939).

Cetraria glauca, *C. islandica*, *Cladonia impexa* subsp. *laxiuscula*, *C. sylvatica*, *C. uncialis*, *Dermatocarpon fluviatile*, *D. miniatum*,[*] *Gyalecta jenensis*, *Lecanora atra*, *L. chlarona*, *Lecidea fuscorubens* v. *ochracea*, *L. lithophila*, *L. macrocarpa*, *L. tumida*, *Lobaria pulmonaria*, *Ochrolechia tartarea*, *Parmelia physodes*, *P. sulcata*, *Parmularia muralis*, *Peltigera canina*, *P. polydactyla*, *P. rufescens*, *Pertusaria corallina*, *Physcia caesia*, *Placynthium nigrum*, *Protoblastenia rupestris*, *Toninia cervina* (?),[‡] and *Verrucaria coerulea* (?).[‡]

2. *Southern Group.*

Cetraria chlorophylla, *Cladonia polydactyla*, *C. rangiformis* v. *pungens*, *Evernia prunastri*, *Graphis scripta*, *Lecanora crassula* (?),[‡] *L. expallens*, *Lecidea cyathoides* (?),[‡] *L. fuscoatra*,[§] *L. lurida*,[||] *L. olivacea* f. *elaeochroma*, *Ochrolechia parella* v. *tumidula*, *Parmelia caperata*, *P. fuliginosa* and its v. *laetevirens*, *P. furfuracea* (?),[‡] *P. pertusa*, *P. trichotera* (?),[¶] *Peltigera horizontalis*, *P. praetextata*, *Pertusaria amara*, *P. pertusa*,[§] *P. Wulfenii*, *Physcia tenella* (?),[‡] *Porina lectissima* (?),[‡] *Pyrenula nitida*, *Ramalina calicaris*,[**] *R. farinacea*, *R. fraxinea*, *Rhizocarpon concentricum*,[§] *R. Hochstetteri* (?),[‡] *R. obscuratum*,[§] *R. Oederi* (?),[‡] *Rinodina confragosa* (?),[‡] *Stereocaulon coralloides*,[††] *S. pileatum*, and *Verrucaria macrostoma*.[**]

3. *Northern Group.*

Alectoria pubescens, *Aspicilia lacustris*,[§] *Cetraria fahlunensis*, *Cladonia bellidiflora*, *C. coccifera*, *Coriscium viride*,[§] *Haematomma*

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[*] There is some doubt concerning the northern limit of this species. Degelius and Magnusson state that it is a southern plant in Scandinavia. It has been repeatedly recorded from the Arctic, but Lynge (in Vid. Akad. Skr. M. N. Kl., no. 6, p. 33, 1938) has shown that these records are for the most part referable to another closely allied species, *D. polyphyllum*: in the Greenland collections studied by him it was found only in the extreme south-west of the continent. Nevertheless the true *D. miniatum* has been identified by me from icebound nunataks at high altitudes in East Greenland (Nytt Mag. Naturvidensk., lxxx, p. 266, 1939), which seems to contradict the argument that it is necessarily southern in its distribution.

[‡] Distribution very imperfectly known.

[§] Not well marked.

[||] Common in Central and Southern Europe, and distinctly southern in Scandinavia, except in oceanic Norway, where the mildness of the climate permits it to penetrate as far north as Finmarken.

[¶] The records for this species are so confused that its European distribution is not well known, in spite of the fact that it is by no means an uncommon plant. Most probably it is a southern oceanic species like the closely related *P. Arnoldii* (see Degelius, 1935).

[**] Appears to be an oceanic species.

[††] Southern limit not precisely known.

ventosum, *Lecanora intricata*, *Lecidea auriculata* v. *diducens*, *L. caesioatra*, *L. lactea*, *L. leucophaea*, *L. pelobotryon*,[*] *L. speirea*, *Mycoblastus sanguinarius*, *Parmelia alpicola*, *P. olivacea*,[†] *Peltigera variolosa*,[‡] *Pertusaria lactea* (?),[§] *Polyblastia scotinospora*, *Rhizocarpon oreites*, *Solorina saccata*,[‡] *Sphaerophorus fragilis*,[‡] *S. globosus*,[‡] *Staurothele fissa*,[‖] *Stereocaulon denudatum*, *Thelidium papulare*, *Umbilicaria cylindrica* v. *fimbriata*, and *U. torrefacta*.

4. *Oceanic Group.*

Lobaria laetevirens, *Nephroma lusitanicum*, *Pannaria rubiginosa*, *Parmelia crinita*, *P. laevigata*, *Parmeliella atlantica*, *P. plumbea*, *Placopsis gelida*, *Spilonema paradoxum* (?),[§] *Stereocaulon evolutum*,[¶] *Sticta limbata*, and *S. sylvatica*.

5. *Eastern Group.*

[This group is not represented in the area, which is not surprising, for eastern species are rare even in Scandinavia.]

There remain in the collection the following species, which I have not been able to include in the above classification on account of our imperfect knowledge concerning their distribution: *Lecanora subrugosa*, *Lecidea mersata*, *Verrucaria aquatilis*, *V. denudata* v. *Mougeotii*, *V. elaeomelaena*, *V. laevata*, and *V.* cfr. *latebrosa*.

Thus 111 of the species can be inserted in the above phytogeographical categories, and their numerical representation may be expressed as follows (percentages to one decimal place):—

1. Ubiquitous . . .	30·6	per cent.
2. Southern . . .	32·4	,,
3. Northern . . .	26·1	,,
4. Oceanic	10·8	,,
5. Eastern . . .	00·0	,,

For comparison with these percentages, I quote here some figures obtained by Degelius (1932) for the composition of the lichen flora

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[*] Appears to be an oceanic species.

[†] Undoubtedly a northern species in Europe, but there is some discrepancy with regard to Hillmann's statement in Rabh. Krypt.-Fl., p. 121 (1936), that it does not occur at high altitudes in Central Europe. One would expect the reverse to hold good.

[‡] Not well marked.

[§] Distribution very imperfectly known.

[‖] Of northern distribution in Europe generally, but has been recorded from Marocco by R.-G. Werner in Bull. Soc. Sci. Nat. Maroc, xvi (1936).

[¶] Degelius, 1935, p. 3, excludes this species from the strictly oceanic group.

(foliose and fruticose species only) of Åsele Lappmark, in southern Swedish Lapland, lying between 63° 53′ and 65° 26′ N. latitude:

1. Ubiquitous	40·3 per cent.	
2. Northern	18·8	(together 32·9 per cent.)
3. Alpine	14·1	
4. Southern	11·5 per cent.	
5. Western	0·5 ,,	(=oceanic)
6. Eastern	3·6 ,,	
7. Not classified	11·0 ,,	

The percentages are not directly comparable because of the inclusion in the latter list of the species of imperfectly known distribution, but after allowance has been made for this they suffice to show the differences in phytogeographic composition due to the more northern and eastern situation. In my list I have not distinguished between the northern and the alpine types, because the demarcation between them is not well marked in western oceanic Europe, and is in any case a difference only of degree; Watson, in his paper on the bryophytes and lichens of Arctic-alpine vegetation (1925), having remarked on the fact that in Scotland a number of the "Highland" phanerogams and cryptogams descend almost to sea-level, and should hence be considered as Arctic rather than alpine. The phenomenon is even more marked in the south-western parts of Ireland.

The effect of difference in altitude becomes apparent when we analyse the Loch Awe and the Ben Cruachan collections separately:

I. Shore of Loch Awe to above Kilchrenan, 110–490 feet (35–150 m.) above sea-level (97 species).

1. Ubiquitous	33·0 per cent.
2. Southern	37·1 ,,
3. Northern	17·5 ,,
4. Oceanic	12·4 ,,

II. Summit of Ben Cruachan 3689 feet (1125 m.) above sea-level (17 species).

1. Ubiquitous	29·4 per cent.
2. Southern	00·0 ,,
3. Northern	70·6 ,,
4. Oceanic	00·0 ,,

Even in the low altitude collection the proportion of northern species is large in view of the relatively southern situation of the area (between 56 and 57 degrees N. latitude). It may well be that the explanation of this is to be sought in the fact noted above, that Arctic species which are alpine on the continent of Europe are not necessarily restricted to mountainous parts in the hyperoceanic regions of the west. Degelius (1939) has found this to be so with the majority of the alpine species represented on the island of Norra Skaftön, off the coast of S.W. Sweden, and uses for them the term "alpine-maritime." It is obviously a phenomenon requiring further investigation.

SYSTEMATIC LIST OF THE LICHENS COLLECTED.

(*Note*: as A. Lorrain Smith's "Monograph of the British Lichens" is still the most valuable guide to the lichen flora of these islands, I have included in brackets after each species the name under which it is dealt with in that work, where the name is not in accordance with modern lichenological nomenclature.)

Verrucariaceae.

1. *Verrucaria aquatilis* Mudd.—Shore of Loch Awe near North Port Sonachan, on a stone completely submerged in a stream flowing into the lake, 11.VI.1940 (no. 1030). Fertile. New to Argyllshire.

2. *V. coerulea* DC.—Open hillside above Kilchrenan, alt. 500 ft. (150 m.), on metamorphic limestone, 7.VI.1940 (nos. 933, 934 pr.p., 942 pr.p.). Fertile. Nos. 933 and 934 pr.p. are the brownish grey phase of the species—f. *cineracea* (Mudd) Arn.; no. 942 pr.p. is typical as regards the thallus, but it is of interest to note that some of the older spores were distinctly 1-septate, thus showing a transition towards the genus *Thelidium*.

3. *V. denudata* Zschacke, var. *Mougeotii* Zschacke.—Shore of Loch Awe near North Port Sonachan, on a stone completely submerged in a stream flowing into the lake, 11.VI.1940 (no. 1028). Fertile. New to the British Isles. It differs from *V. submersa* in the olive-greenish, shining thallus (sordid whitish-green and matt in *V. submersa*).

4. *V. elaeomelaena* (Mass.) Arn. ("*V. hydrela*" in A. L. Sm. Monogr.).—Together with the foregoing (no. 1029). Fertile. New to Argyllshire.

5. *V. laevata* Ach.—Together with the foregoing, but not completely submerged (no. 1027). Fertile. New to Argyllshire.

6. *V.* cfr. *latebrosa* Kbr.—Shore of Loch Awe near North Port

Sonachan, on an outcrop of schistose rock a few feet above normal water level, together with *Spilonema paradoxum*, 8.VI.1940 (no. 963). Fertile. New to Argyllshire, if the determination be correct. Not having seen an authentic specimen of this species, I am not certain of its identity, but it agrees with the description given by Zschacke in Rabh. Krypt.-Fl., ix, Abt. 1, p. 254 (1934).

7. *V. macrostoma* Duf.—Open hillside above Kilchrenan, alt. 500 ft. (150 m.), on a sloping limestone rock beside a stream, 7.VI.1940 (no. 944). Fertile. New to Argyllshire.

8. *Thelidium papulare* (Fr.) Arn.—Together with the foregoing (no. 943). Fertile. New to Argyllshire.

9. *Polyblastia scotinospora* (Nyl.) Hellb.—Shore of Loch Awe near North Port Sonachan, on an outcrop of schistose rock a few feet above normal water level, 8.VI.1940 (no. 964). Fertile. New to Argyllshire. The thallus is rather thick, rimulose-areolate, and so the specimen may be referred to the f. *britannica* Vain., Lich. Fennic., i, p. 99 (1921). Concerning the differences between this species and *P. subinumbrata* (Nyl.) A. L. Sm., see Watson's note in Journ. Bot., lxxvii, p. 42 (1939).

10. *Staurothele fissa* (Tayl.) Zwackh. (*S. umbrinum* A. L. Sm.).—Shore of Loch Awe near North Port Sonachan, on rocks at and slightly above normal water level, associated with the moss *Cinclidotus fontinaloides* P. Beauv., 8.VI.1940 (no. 968). Fertile. New to Argyllshire.

Dermatocarpaceae.

11. *Dermatocarpon fluviatile* (Web.) Th. Fr. (*D. aquaticum* Zahlbr.).—Shore of Loch Awe near North Port Sonachan, on rocks just above normal water level, 9.VI.1940 (no. 994) and 15.VI.1940 (no. 1066). Fertile.

12. *D. miniatum* (L.) Mann.—Together with the foregoing, slightly higher up, 15.VI.1940 (no. 1067). Fertile. Partly the typical form and partly var. *complicatum* (Lightf.) Th. Fr.

Pyrenulaceae.

13. *Porina lectissima* (Fr.) Zahlbr.—Shore of Loch Awe near North Port Sonachan, on a sloping schistose rock rather shaded by trees, 11.VI.1940 (no. 1025). Fertile.

14. *Pyrenula nitida* (Weig.) Ach.—Shore of Loch Awe near North Port Sonachan, on the smooth bark of *Corylus* in a mixed wood, 11.VI.1940 (no. 1023). Fertile.

Pyrenidiaceae.

15. *Coriscium viride* (Ach.) Vain.—Summit of Ben Cruachan, alt. 3689 feet (1125 m.), over mosses between granite boulders, 12.VI.1940 (no. 1050). Sterile, as always.

Sphaerophoraceae.

16. *Sphaerophorus fragilis* (L.) Pers.—Shore of Loch Awe near North Port Sonachan, on summits of schistose rocks above the highest water level, 5.VI.1940 (no. 916). Sterile.

17. *S. globosus* (Huds.) Vain.—Open hillside near North Port Sonachan, alt. 250 feet (76 m.), on the schistose blocks of a field wall, 9.VI.1940 (no. 975). Sterile.

Arthoniaceae.

18. *Arthonia* sp.—Shore of Loch Awe near North Port Sonachan, on the trunk of *Fraxinus*, 9.VI.1940 (no. 981). Fertile. It belongs to sect. *Chromatocarpia* subsect. *Coniocarpon*, and approaches *A. stellaris* Kphbr., but neither Dr. Watson nor myself have been able to identify it satisfactorily.

Graphidaceae.

19. *Graphis scripta* (L.) Ach.—Together with the foregoing (no. 982). Fertile.

Gyalectaceae.

20. *Gyalecta jenensis* (Batsch) Zahlbr. (*G. cupularis* Schaer.).—Open hillside above Kilchrenan, alt. 500 ft. (150 m.), on metamorphic limestone, 7.VI.1940 (nos. 936, 938). Fertile.

Ephebaceae.

21. *Spilonema paradoxum* Born.—Shore of Loch Awe near North Port Sonachan, on an outcrop of schistose rock, a few feet above normal water level, 8.VI.1940 (no. 962). Sterile.

Pannariaceae.

22. *Placynthium nigrum* (Huds.) Gray.—Open hillside above North Port Sonachan, alt. 250 ft. (76 m.), on a piece of calc sinter in a moraine, 10.VI.1940 (no. 1014). Sterile.

23. *Parmeliella atlantica* Degel. (*P. plumbea* pr.p. in A. L. Sm. Monogr.).—Shore of Loch Awe near North Port Sonachan, a stone's throw behind the foreshore, on mossy trunk of *Corylus* at the edge

of a field, 10.VI.1940 (no. 1003). Sterile. This extremely oceanic species, which differs from *P. plumbea* in its isidiate thallus, was first described by Degelius in Acta Phytogeogr. Suecica, vii (1935), from Norway, Eire, and Portugal. In Journ. Bot., lxxiv, p. 175 (1936), I recorded it from four further localities in England and Scotland, one of which was in Argyll (Airds, Appin, collected by Crombie). Subsequently Köfaragó-Gyelnik in Borbasia, i, p. 44 (1939), published an interesting Mediterranean record from Croatia, Velebit, on the Adriatic coast. On p. 205 of this number (1942) Dr. Watson expresses the opinion that it should be considered as an isidioid form of *P. plumbea.*

24. *P. plumbea* (Lightf.) Müll. Arg.—Shore of Loch Awe near North Port Sonachan, on trunk of *Fraxinus*, 6. and 8.VI.1940 (nos. 918, 947), and on an outcrop of schistose rock, 8.VI.1940 (no. 961). Fertile. An oceanic species; its distribution in Europe is similar to that of *Nephroma lusitanicum.* In nos. 918 and 961 the apothecia are dark in colour, almost black.

25. *Pannaria rubiginosa* (Thunb.) Del.—Shore of Loch Awe near North Port Sonachan, on trunk of *Corylus* in a field, 10.VI.1940 (no. 1008). Fertile.

Stictaceae.

26. *Lobaria laetevirens* (Lightf.) Zahlbr.—Shore of Loch Awe near North Port Sonachan, on trunk of *Fraxinus*, 8. and 10.VI.1940 (nos. 948, 995). Fertile.

27. *L. pulmonaria* (L.) Hoffm.–Roadside by North Port Sonachan, near the shore of the lake, on trunk of *Fraxinus*, 8.VI.1940 (no. 946). Fertile. Medulla K + yellow, C –, K(C) as with K alone, Pd + yellow then brick-red (stictic acid, $C_{18}H_{14}O_9$). Asahina in Acta Phytochim., viii, p. 59 (1934), and Schindler in Ber. Deutsch. Bot. Ges., liv, p. 240 (1936), have shown that this species may produce in its medulla not only stictic acid, but also norstictic acid ($C_{19}H_{14}O_9$) and gyrophoric acid ($C_{24}H_{20}O_{10}$), the presence or absence of these accessory constituents showing little or no correlation with geographical distribution or morphological differentiation.

28. *Sticta limbata* (Sm.) Ach.—Shore of Loch Awe near North Port Sonachan, growing over the hepatic *Frullania Tamarisci* on trunk of *Quercus* in light mixed wood, 6.VI.1940 (no. 931). Sterile, as always.

29. *S. sylvatica* (Huds.) Ach.—Together with the foregoing (no. 932); also farther along the shore, on a mossy boulder in the mixed wood, 11.VI.1940 (no. 1024). Sterile.

Peltigeraceae.

30. *Solorina saccata* (L.) Ach.—Open hillside above Kilchrenan, alt. 500 ft. (150 m.), on earth in crevices of limestone rock, 7.VI.1940 (no. 935). Fertile.

31. *Nephroma lusitanicum* Schaer.—Shore of Loch Awe near North Port Sonachan, on trunk of *Corylus*, 10.VI.1940 (no. 1004), and on a sloping rock a few feet above normal water level, 15.VI.1940 (no. 1065). Fertile.

32. *Peltigera canina* (L.) Willd.—Shore of Loch Awe near North Port Sonachan, on a mossy boulder in light mixed wood, 8.VI.1940 (no. 951). Sterile.

33. *P. horizontalis* (L.) Baumg.—Shore of Loch Awe near North Port Sonachan, on trunk of *Fraxinus* in mixed wood (no. 998), and on a mossy boulder (no. 1001), 10.VI.1940. Fertile.

34. *P. polydactyla* (Neck.) Hoffm.—Open hillside above Kilchrenan, alt. 500 ft. (150 m.), on a granite boulder beside a stream, 7.VI.1940 (no. 945). Sterile.

35. *P. praetextata* (Flk.) Zopf emend. Gyel. (*P. rufescens* v. *praetextata* Nyl.).—Shore of Loch Awe near North Port Sonachan, on a mossy boulder in the mixed wood, 10.VI.1940 (no. 1000). Sterile.

36. *P. rufescens* (Weis) Humb.—Together with the foregoing (no. 999). Sterile.

37. *P. variolosa* (Mass.) Gyel. (*P. aphthosa* v. *leucophlebia* Nyl.). —Shore of Loch Awe near North Port Sonachan, on an outcrop of schistose rock among grass at the back of the foreshore, 6.VI.1940 (no. 929). Sterile. This species differs from *P. aphthosa* in the distinct, anastomosing nervation of the underside.

Lecideaceae.

38. *Lecidea* (*Eulecidea*) *auriculata* Th. Fr., v. *diducens* (Nyl.) Th. Fr.—Summit of Ben Cruachan, alt. 3689 ft. (1125 m.), on a granite boulder, 12.VI.1940 (no. 1041). Fertile. New to Argyllshire.

39. *L. caesioatra* Schaer. (*L. arctica* Smrft.).—Summit of Ben Cruachan, over mosses between granite boulders, 12.VI.1940 (no. 1049). Fertile.

40. *L. fuscoatra* (L.) Ach.—Open hillside near North Port Sonachan, alt. 250 ft. (76 m.), on the schistose blocks of a field wall, 9.VI.1940 (no. 978), and near Barbreck Farm, alt. 350 ft. (107 m.), on a schistose outcrop, 16.VI.1940 (no. 1070). Fertile. No. 1070 is a pale coloured form, giving no reaction with $CaCl_2O_2$.

41. *L. lactea* Flk. (*L. lapicida* pr.p. in A. L. Sm. Monogr.).—Summit of Ben Cruachan, alt. 3689 ft. (1125 m.), on a granite boulder, 12.VI.1940 (no. 1034). Fertile. *L. lactea* Flk. is the correct name for this plant which is often called *L. pantherina*; Vainio, in Lich. Fennic., iv, p. 119 (1934), having shown that Hoffmann's "*Verrucaria pantherina*" does not belong here, but the name which he uses, *L. cyanea* (Ach.) Vain., although based on the earliest epithet, is also not admissible because the original description of Acharius refers to a subspecies. Only sparingly gathered, growing together with *Rhizocarpon oreites*.

42. *L. lithophila* Th. Fr.—Open hillside near North Port Sonachan, alt. 250 ft. (76 m.), on a small boulder in a moraine, 10.VI.1940 (no. 1013), alt. 350 ft. (105 m.), on stone in another moraine, 11.VI.1940 (no. 1031), and on a boulder in a pasture field, alt. 250 ft. (76 m.), 15.VI.1940 (no. 1060). Fertile. Nos. 1031 and 1060 are the f. *ochracea* Arn. "*Lecidea lithophila* (Ach.) Th. Fr." is a well-known name, but according to Vainio, Lich. Fennic., iv, p. 137 (1934), it is not strictly correct, as the original material of Acharius does not include this species. The same applies to the "f. *ochracea* Arn.," supposed to be based on Acharius's "*Lecidea daphoena β. L. ochracea*," which is, however, something entirely different (see Vainio's remarks, *loc. cit.*).

43. *L. macrocarpa* (DC.) Steud. (*L. contigua* Fr.).—Open hillside above Kilchrenan, alt. 500 ft. (150 m.), on metamorphic limestone, 7.VI.1940 (no. 939); hillside above North Port Sonachan, alt. 250 ft. (76 m.), on schistose blocks of a field wall, 9.VI.1940 (no. 974); at another point on the same slope, 15.VI.1940 (no. 1062). Fertile. No. 939, on limestone, is that thick-crusted, whitish variety of calcareous rocks which has gone under the name of "*Lecidea contigua* var. *calcarea* Fr." This is not a valid epithet, however, for Fries, Lichenogr. Europ. Reform., p. 302 (1831), cites as a synonym the "*Lichen calcareus*" of Weis, which is *Rhizocarpon calcareum*, and is in its turn a homonym of the Linnaean "*Lichen calcareus*" (*Aspicilia calcarea*). I do not know of any other epithet which can be applied with certainty to the present variety.

44. *L. mersata* Stirt.—Shore of Loch Awe near North Port Sonachan, on small boulders at and slightly above normal water level, associated with *Aspicilia lacustris*, 6.VI.1940 (no. 926). Fertile. I am indebted to Dr. Watson for this determination. This was the only specimen gathered, but the sterile thallus was seen in several places, always in the *Aspicilia lacustris*-zone subject to periodical inundation. R. Santesson, in his recent paper on the zonation

of lacustrine lichens in Sweden (1939), mentions the following lichens as of common occurrence in the *Aspicilia lacustris*-zone of some Swedish lakes: *Bacidia inundata*, *Lecidea coarctata*, *L. sorediza* (=*L. tumida*), and *Rhizocarpon obscuratum*. None of these species was found by me together with *A. lacustris* at the margins of Loch Awe, although *Rhizocarpon obscuratum* was often present on rocks higher up, some feet above the normal water level. *Lecidea mersata* has been previously reported from the following localities: England, Cornwall, the Lizard (Watson in Journ. Bot., lxxvii, p. 33 (1939)) *; Brecon, Taren yr Esgob; Cumberland, rocks at the margins of Lake Buttermere (both records from Watson *in litt.*); Scotland, Perthshire, on submerged granitic rocks in Loch Rannoch (Stirton in Scottish Naturalist, v, p. 218 (1880)); Argyllshire, "on stones, sometimes submerged, on shore of Loch Tulla" (Watson in Journ. Bot., lxvii, p. 78 (1929)); Inverness, Skye, Sciur-na-Gillean (Watson, *supra*, p. 193); Orkney, Stromness (Watson *in litt.*). It is a species which should be looked for on the rocky shores of lakes in other parts of Europe. The thallus strongly resembles that of *Lecidea albocoerulescens*, being effuse or subdeterminate, leaden-grey, caesious-grey, or glaucous, smooth or slightly tumid-verrucose, not areolate, but often with anastomosing cracks, with both surface and medulla KHO –, $CaCl_2O_2$ –, KHO($CaCl_2O_2$) –, I –, Pd –. Apothecia up to 2 mm. or even larger, sessile, entirely black, sometimes pruinose, usually becoming more or less convex and immarginate. Excipulum entire, brown, with radiating structure; hypothecium dark brown-black, paraplectenchymatic; thecium about 105–140 μ high, gradually clear blue-green or blue-green-blackish in upper part. Paraphyses subdiscrete, regular, 1·5–2·5 μ thick, slightly thicker at tips (up to 4 μ). Spores 8, elongate-ellipsoid, 18–23 × (6–)7·5–8·0(–9) μ. "Spermogonia often present and sometimes ± linearly arranged" (Watson *in litt.*). Originally I had considered the possibility of *L. albocoerulescens* v. *smaragdula* Knowles, apud A. L. Smith, Monogr. Brit. Lich., ed. 2, i, p. 470 (1918), but on examining the type specimen in the British Museum Herbarium I found it to be identical with *L. macrocarpa* v. *hydrophila* (Fr.) Vain., having a scattered, diffuse, milk-white thallus entirely different in appearance from that of *L. albocoerulescens*.

45. *L. olivacea* (Hoffm.) Mass., f. *elaeochroma* (Ach.) Vain. (*L. parasema* v. *elaeochroma* Ach.).—Shore of Loch Awe near North Port Sonachan, on trunk of *Alnus*, 8.VI.1940 (no. 959). Fertile.

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* Dr. Watson informs me *in litt.* that this Lizard record may be incorrect, on account of a possible confusion of collecting labels.

46. *L. pelobotryon* (Wbg.) Leight. (*Lecanora pelobotrya* Smrft.).—Open hillside above North Port Sonachan, alt. 350 ft. (105 m.), on a stone in a moraine, 11.VI.1940 (no. 1032). Fertile. I believe that *Lecidea pelobotryon* and *L. consentiens* Nyl. are the same species. Th. Fries, in Lich. Scandin., i, p. 504 (1874), stated that the two species could be distinguished by their reactions with calcium hypochlorite—*pelobotryon* being $CaCl_2O_2$ + red, *consentiens* $CaCl_2O_2$ –. A. L. Smith, Monogr. Brit. Lich., ed. 2, i, p. 319 (1918), indicates that in "*Lecanora pelobotrya*" the reaction is negative. Lynge at one time thought that the two species could be distinguished chemically ("Lichens from Bear Island," in Res. Norsk. Statsunderstött. Spitsbergeneksped., i, no. 9, pp. 19–20 (1926)), but subsequently, in his "Lichens from Jan Mayen" (Skr. Svalb. og Isbavet, no. 76 (1939)), on p. 16, he describes his difficulty in obtaining the $CaCl_2O_2$ reaction, and is therefore thrown back on the alleged morphological difference (chiefly degree of immersion of the apothecia) in attempting to separate the two "species." The truth is that *L. pelobotryon* is fluctuating in its $CaCl_2O_2$ reaction, sometimes positive and sometimes negative. There is supposed to be a distinction also in spore-size (20–30 × 12–16 μ in *pelobotryon*, 27–38 × 16–22 μ in *consentiens*), but examination of a good deal of material shows that all intergradations between these sizes exist. Therefore it seems that one rather variable species, and not two, are indicated. All the British material called "*Lecidea panaeola*" in the British Museum Herbarium proves on examination to belong also to this species. A. L. Smith, Monogr. Brit. Lich., ed. 2, ii, p. 79 (1926), states that "*Lecidea panaeola* var. *β. elegans* Th. Fr." (= *Lecidea elegans* Vain. Lich. Fennic., iv, p. 151 (1934)) occurs "rarely on the Scottish mountains," but this statement is not confirmed by a study of the material in question. I also had the opportunity of examining the material called "*Lecidea panaeola*" in herb. Leighton (Kew), and found that all of it also was referable to *L. pelobotryon*. Hence it is doubtful whether the true *L. panaeola* occurs at all in the British Isles. Leighton, in his Lich. Fl. Gr. Brit., ed. 3, pp. 284–5 (1879), described three forms of *L. panaeola*: *obliterata* Leight., *subconsentiens* Leight., and *vera* Leight. There is no material in his herbarium labelled "*vera*," and it is obvious that he was using this name to designate the typical form of the species. Type material of f. *subconsentiens* is present from several Welsh localities. It is the state of *L. pelobotryon* in which the apothecia are permanently immersed in the areolae and overtopped by a slightly tumid, spurious thalline margin; the black discs are

0·5 1·0 mm. diam. In the specimen from Cwm Ffynnon Llugwy the spores are 24–34 × 14–17 μ. *F. obliterata* Leight. is represented by one specimen, from Cwm Cywion; the thallus is patchy, in the form of minute confluent islands, very thin (not over 0·2 mm. thick), not distinctly areolate, but in places with cracks anastomosing to form imperfect areolation; effuse, having in general an eroded appearance when viewed under a lens. I could get no reaction with $CaCl_2O_2$. Apothecia numerous, small (0·3–0·7 mm. diam.), at first innate in the thallus and crowned by a thin pseudothalline margin, then becoming innate-sessile with a prominent black proper margin, the pseudothalline margin finally disappearing altogether. Spores 25–28 × 14·5 15·0 μ. Cephalodia present, 0·8–1·2 mm. diam., flattened, concolorous with the thallus, not lobate. The two forms seem sufficiently distinct to merit transfer to *L. pelobotryon*:

Lecidea pelobotryon f. *obliterata* (Leight.) M. Lamb, **comb. nov.**
,, ,, f. *subconsentiens* (Leight.) M. Lamb, **comb. nov.**

47. *L. speirea* (Ach.) Ach. (*L. cinerascens* A. L. Sm.).—Shore of Loch Awe near North Port Sonachan, on a schistose outcrop above the highest water level, together with *Parmelia saxatilis*, 6.VI.1940 (no. 927). Fertile. A. L. Smith, Monogr. Brit. Lich., ii, p. 73 (1911), makes the combination *L. cinerascens* (With.) A. L. Sm. for this species, founded upon *Lichen cinerascens* Withering, Arr. Brit. Pl., ed. 3, iv, p. 8 (1796). The combination cannot be used, however, because it is a homonym of *Lecidea cinerascens* Nyl. in Mém. Soc. Sci. Nat. Cherbourg, iii, p. 185 (1855), i.e. *Schismatomma cinerascens* (Nyl.) Zahlbr.

48. *L. tumida* Mass. (*L. sorediza* Nyl.).—Roadside at North Port Sonachan, on a stone gatepost, 4.VI.1940 (no. 912), sterile; open hillside above North Port Sonachan, alt. 250 ft. (76 m.), on small boulders in a moraine, 10.VI.1940 (nos. 1011, 1012); summit of Ben Cruachan, alt. 3689 ft. (1125 m.), on a granite boulder, 12.VI.1940 (no. 1051). Fertile. Nos. 1011, 1012, and 1051 represent the typical form of the species, with naked apothecial discs. The soredia are often poorly developed. New to Argyllshire.

49. *L.* (*Biatora*) *cyathoides* Ach. (*L. rivulosa* Ach.).—Near Barbreck Farm, alt. 350 ft. (107 m.), on a schistose outcrop, 16.VI.1940 (no. 1069). Fertile.

50. *L. fuscorubens* (Nyl.) Nyl., v. *ochracea* (Hepp) Vain.—Open hillside above Kilchrenan, alt. 500 ft. (150 m.), on metamorphic limestone, 7.VI.1940 (no. 942 pr.p.). Fertile. Intimately associated with *Verrucaria coerulea*.

51. *L. leucophaea* (Flk.) Nyl.—Open hillside near North Port Sonachan, alt. 250 ft. (76 m.), on the schistose blocks of a field wall, 9.VI.1940 (no. 972). Fertile.

52. *L.* (*Psora*) *lurida* (Sw.) Ach.—Shore of Loch Awe near North Port Sonachan, growing over detritus in cracks between rocks at the back of the shore, 9.VI.1940 (no. 991). Sterile. New to Argyllshire.

53. *Mycoblastus sanguinarius* (L.) Norm. (*Lecidea sanguinaria* Ach.).—Open hillside behind North Port Sonachan, alt. 300 ft. (93 m.), on the side of a boulder in the pasture, covering an area of the rock as large as two hands, 15.VI.1940 (no. 1059). Fertile.

54. *Catillaria chalybeia* (Borr.) Mass. (*Biatorina chalybeia* Mudd). —Shore of Loch Awe near North Port Sonachan, on small boulders at and above normal water level, together with *Aspicilia lacustris*, 9.VI.1940 (no. 989); farther along the shore, on trunk of *Alnus*, 8.VI.1940 (no. 955). Fertile. New to Argyllshire.

55. *Bacidia melaena* (Nyl.) Zahlbr. (*Bilimbia melaena* Arn.).—Summit of Ben Cruachan, alt. 3689 ft. (1125 m.), over mosses between granite boulders, 12.VI.1940 (no. 1046). Fertile.

56. *Toninia cervina* Lönnr. (*Bilimbia carbonacea* Jatta).—Open hillside above Kilchrenan, alt. 500 ft. (150 m.), on metamorphic limestone, on the underside of an overhanging ledge, 7.VI.1940 (no. 941). Fertile. The specimen shows perfect agreement, both externally and internally, with Anzi's Lich. rar. Langob., no. 115 ("*Toninia carbonacea*"). This species is outwardly hardly distinguishable from *T. aromatica* (Turn.) Mass., but on microscopical examination is quite distinct by the purple-blackish epithecium (smaragdine or blue-green in *T. aromatica*). The epithecium of *T. cervina* is formed of the "Lecanora-red" of Bachmann, while that of *T. aromatica* is "Lecidea-green."

57. *Rhizocarpon* (*Eurhizocarpon*) *concentricum* (Dav.) Beltr. (*R. petraeum* Mass.).—Open hillside above Kilchrenan, alt. 500 ft. (150 m.), on metamorphic limestone, 7.VI.1940 (no. 937). Fertile.

58. *R. obscuratum* (Ach.) Mass.—Shore of Loch Awe near North Port Sonachan, on a schistose outcrop above the highest water level, 6.VI.1940 (no. 928) and 8.VI.1940 (no. 960). Fertile.

59. *R. Oederi* (Web.) Kbr.—Open hillside near North Port Sonachan, alt. 250 ft. (76 m.), on the schistose blocks of a field wall, 9.VI.1940 (no. 976). Fertile. New to Argyllshire.

60. *R.* (*Catocarpon*) *Hochstetteri* (Kbr.) Vain. (*Buellia colludens* Tuck.).—Hilltop ("Càrn Bàn") behind North Port Sonachan, alt. 350 ft. (105 m.), on sloping slab of schist beneath larch trees,

together with *Lecanora intricata*, 11.VI.1940 (no. 1021). Fertile. New to Argyllshire.

61. *R. oreites* (Vain.) Zahlbr. (*Buellia alpicola* Kphbr.).—Summit of Ben Cruachan, alt. 3689 ft. (1125 m.), on granite boulders, 12.VI.1940 (no. 1038). Fertile. New to Argyllshire. Two samples of the yellow *Rhizocarpon* occurring on almost every boulder at the summit were taken, and both proved on subsequent microscopical examination to be *R. oreites*. It would have been of interest to have collected a larger number of specimens in order to find out whether *R.* (*Eurhizoc.*) *geographicum* was also present, and, if so, to determine the relative abundance of the two species.

Cladoniaceae.

62. *Baeomyces rufus* (Huds.) Rebent.—Open hillside above Kilchrenan, alt. 500 ft. (150 m.), over soil and decomposed rock on an outcrop of metamorphic limestone, 7.VI.1940 (no. 940). Rudiments of apothecia present.

63. *Cladonia* (*Cladina*) *impexa* Harm. (*C. sylvatica* pr.p. in A. L. Sm. Monogr.), subsp. *laxiuscula* (Del.) Sandst.—Open hillside above North Port Sonachan, alt. 350 ft. (105 m.), in pasture, 10.VI.1940. Sterile.

64. *C. sylvatica* (L.) Hoffm.—Summit of Ben Cruachan. alt. 3689 ft. (1125 m.), among mosses between granite boulders, 12.VI.1940 (no. 1045), and open hillside behind North Port Sonachan, alt. 350 ft. (105 m.), in pasture, 15.VI.1940 (no. 1056). Sterile.

65. *C.* (*Cenomyce*) *bellidiflora* (Ach.) Schaer.—Summit of Ben Cruachan, among mosses between granite boulders, 12.VI.1940 (no. 1047). Sterile.

66. *C. coccifera* (L.) Willd.—Open hillside near North Port Sonachan, alt. 250 ft. (76 m.), on the schistose blocks of a field wall, 9.VI.1940 (no. 980), and on another wall nearby, over mosses, 10.VI.1940 (no. 1007). Rudiments of apothecia present.

67. *C. polydactyla* Flk. (*C. flabelliformis* Vain.).—Open hillside behind North Port Sonachan, alt. 350 ft. (105 m.), on a rotten tree stump at the outskirts of a wood, 15.VI.1940 (no. 1057). Fertile.

68. *C. rangiformis* Hoffm., var. *pungens* (Ach.) Vain.—Shore of Loch Awe near North Port Sonachan, on a mossy boulder in light mixed wood, 6.VI.1940 (no. 923). Sterile. Forming a dense mat of brownish colour. Podetia KHO + yellow, *Pd + orange-red*. This reaction with paraphenylenediamine might lead one to suspect *C. subrangiformis* Scriba, which has not yet been found in Britain,

but the morphology of the specimen (habit, variegated cortex of podetia, etc.) is very characteristic of *C. rangiformis*, to which it obviously belongs. Des Abbayes has recently shown in Bull. Soc. Sci. Bretagne, xiv, p. 158 (1937), that *C. rangiformis* may sometimes give a positive paraphenylenediamine reaction.

69. *C. uncialis* (L.) Web.—Open hillside behind North Port Sonachan, alt. 350 ft. (105 m.), in pasture, 15.VI.1940 (no. 1055). Sterile.

70. *Stereocaulon coralloides* Fr.—Open hillside near North Port Sonachan, alt. 250 ft. (76 m.), on a small boulder in a moraine, 10.VI.1940 (no. 1009). Fertile.

71. *S. denudatum* Flk.—Slopes of Ben Cruachan, alt. 2250 ft. (686 m.), on detritus on a granite boulder, 12.VI.1940 (no. 1052). Sterile.

Var. *umbricolum* Frey.—Summit of Ben Cruachan, alt. 3689 ft. (1125 m.), over mosses on granite boulder, 12.VI.1940 (no. 1044). Sterile. New to the British Isles. This variety, described by Frey in Rabh. Krypt.-Fl., ix. Abt. iv. 1 Hälfte, p. 134 (1933), is characterised by the conglomerated, small, subglobose phyllocladia, which usually lack the dark spot in the centre. It is therefore rather easy to confuse specimens of this variety with *S. alpinum*, although the absence of tomentum should prevent this. In my specimen a few of the phyllocladia show the darker centres, and this, in conjunction with the characteristic orange reaction with Pd, leaves no doubt as to the specific identity. The Pd reaction excludes *S. paschale*, in which the phyllocladia are Pd – or at most faintly yellow, never orange. With regard to *S. alpinum*, the Pd reaction requires further investigation; in by far the greater part of the material which I have tested (both European and Arctic), the phyllocladia are Pd –, but two specimens, one from Novaya Zemlya, coll. Lynge, 1921, the other from S.E. Greenland, coll. Scholander, 1932, both in morphological characters undoubtedly *S. alpinum*, have the phyllocladia Pd + orange. Apparently therefore there are chemically distinct strains of this species.

72. *S. evolutum* Graewe.—Shore of Loch Awe near North Port Sonachan, on summits of schistose rocks above the highest water level, 5.VI.1940 (no. 917), and on the open hillside nearby, alt. 250 ft. (76 m.), on detritus on a field wall, 10.VI.1940 (no. 1005). Fertile.

73. *S. pileatum* Ach.—Open hillside above North Port Sonachan, alt. 250 ft. (76 m.), on schistose blocks of a field wall, associated with *Placopsis gelida*, 10.VI.1940 (no. 1006). Sterile. In this species the phyllocladia are Pd + (slowly) faint yellow.

Gyrophoraceae.

74. *Umbilicaria cylindrica* (L.) Del. (*Gyrophora cylindrica* Ach.). var. *fimbriata* (Ach.) Nyl.—Summit of Ben Cruachan, alt. 3689 ft. (1125 m.), on granite boulders, 12.VI.1940 (no. 1035). Fertile. The v. *fimbriata* is new to Argyllshire. It was abundant on the summit, very polyphyllous, and therefore difficult to detach in its entirety from the rock.

75. *U. torrefacta* (Lightf.) Schrad. (*Gyrophora torrefacta* Cromb.). —Together with the foregoing, but much less abundant (no. 1037). Sterile. As Lynge has pointed out in Medd. om Grønland, cxviii, p. 111 (1937), the valid epithet for this species is *torrefacta*, not *erosa*, because Lightfoot published the former in 1777, one year previous to the publication of Weber's "*Lichen erosus.*"

Acarosporaceae.

76. *Acarospora* sp.—Shore of Loch Awe near North Port Sonachan, on a large schistose boulder at the back of the shore, possibly within reach of the highest water level, 9.VI.1940 (no. 990). Fertile. A superficial growth of Cyanophyceous algae gives it a strong resemblance to a *Pyrenopsis*, as which it was collected. It may possibly be a state of *A. pyrenopsoides* H. Magn., but I have seen no material of that species, and the internal characters are not in exact agreement.

Pertusariaceae.

77. *Pertusaria amara* (Ach.) Nyl. (*P. faginea* Leight.).—Shore of Loch Awe near North Port Sonachan, on trunk of *Acer pseudoplatanus*, 9.VI.1940 (no. 984). Sterile.

78. *P. corallina* (L.) Arn. (*P. dealbata* f. *corallina* Cromb.).—Open hillside above North Port Sonachan, alt. 250 ft. (76 m.), on schistose blocks of a field wall, 9.VI.1940 (no. 971), fertile, and summit of Ben Cruachan, alt. 3689 ft. (1125 m.), on a granite boulder, 12.VI.1940 (no. 1042), sterile. In the Ben Cruachan specimen the thallus is thickly strewn with the black, apothecia-like fruit-bodies of *Coniothecium sphaerale* (Fr.) Keissl. ("*Cyphelium stigonellum*" in A. L. Sm. Monogr.). Such parasitised individuals of *P. corallina* are sometimes referred to a distinct form, f. *papillosa* (Ach.) Zahlbr.

79. *P. lactea* (L.) Arn.—Shore of Loch Awe near North Port Sonachan, on an outcrop of schistose rock above the highest water level, 8.VI.1940 (no. 966). Sterile. New to Argyllshire.

80. *P. pertusa* (L.) Tuck.—Shore of Loch Awe near North Port Sonachan, on trunk of *Acer pseudoplatanus*, 9.VI.1940 (no. 983). Fertile.

81. *P. Wulfenii* DC.—On another tree of *Acer pseudoplatanus* in the same place as the foregoing, 9.VI.1940 (no. 985). Fertile. The fertile warts of this specimen are sparsely scattered over the thin, slightly wrinkled thallus, and so it is referable to the f. *sparsa* Erichs. in Rabh. Krypt.-Fl., ix, Abt. v, Teil 1, p. 441 (1935), a form not until now noted in the British Isles.

Lecanoraceae.

82. *Lecanora atra* (Huds.) Ach.—Shore of Loch Awe near North Port Sonachan, on an outcrop of schistose rock above the highest water level, 8.VI.1940 (no. 965). Fertile. New to Argyllshire.

83. *L. chlarona* (Ach.) Nyl. (*L. subfusca* v. *chlarona* Ach.).—Roadside by North Port Sonachan, near the shore of the lake, on trunk of *Fraxinus*, 8.VI.1940 (no. 949). Fertile. Many of the apothecial discs have been completely eaten away (by snails?).

84. *L. crassula* H. Magn.—Shore of Loch Awe near North Port Sonachan, on trunk of *Alnus*, 8.VI.1940 (no. 969). Fertile. New to Argyllshire. This species, first described by Magnusson in Acta Horti Gothoburg., vii, p. 80 (1932), is similar to *L. chlarona*, but differs chiefly in the epithecium, which owes its yellow-brown colour to a deposit of minute, sordid yellowish granules; on application of KHO these disappear entirely, leaving the thecium quite colourless. Magnusson, in his revision of the species of the *Lecanora subfusca*-group (*loc. cit.*), distinguishes three different types of epithecium: (1) the *glabrata*-type, found in *L. glabrata*, *L. subfuscata*, and *L. subrugosa*, in which the upper part of the thecium is reddish brown, without granules, the colour becoming somewhat paler but not disappearing in KHO; (2) the *pinastri*-type, occurring in *L. pinastri*, *L. chlarona*, and *L. coilocarpa*; in this type, according to Magnusson, the yellow-brown colour of the upper thecium is due to the presence of minute granules embedded in the mucilage between the paraphyses; (3) the *rugosella*-type, comprising *L. rugosella*, *L. chlarotera*, *L. crassula*, and *L. meridionalis*, these having an epithecium of ± coarse, yellowish granules lying mostly on top of the thecium. In (2) and (3) the epithecial colour disappears completely or almost so in KHO. After the examination of a large number of specimens, I find myself unable to agree with Magnusson's statement concerning the presence of minute granules in the *pinastri*-type, at any rate as far as *L. chlarona* is

concerned. In well-authenticated specimens of this species examined (such as Norrl. and Nyl. Herb. Lich. Fenn., no. 133, and Magn. Lich. sel. Scand. exs., no. 160), as well as others from my own collections, no trace of any granules could be seen even with the highest powers of the microscope. Rather the yellow-brown coloration in the upper part of the thecium is due to a pigment secreted into the mucilage surrounding the tips of the paraphyses (fig. 4, A). In the *rugosella*-type, on the other hand, the epithecium of minute, sordid yellowish granules is very distinct (fig. 4, B). This difference makes it easy to distinguish between the two groups, even in an aqueous squashed preparation. *L. crassula* has already been recorded from the British Isles by Magnusson, *loc. cit.* (Ireland, exact locality not given).

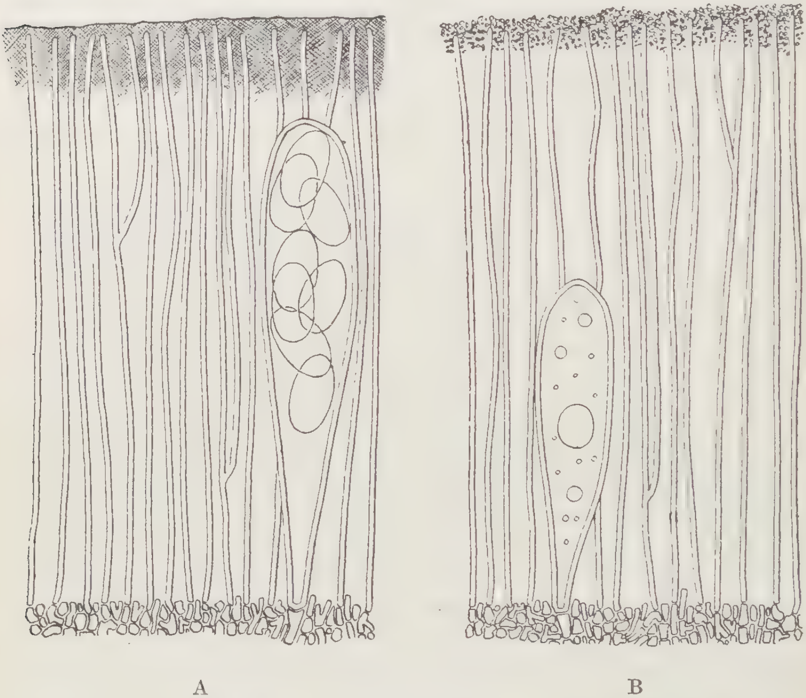

A B

FIG. 4.—A: Vertical section through a thecium of the *Lecanora pinastri*-type (*L. chlarona*); the epithecial coloration is due to a yellow-brown pigment secreted in the mucilage surrounding the tips of the paraphyses. B: Vertical section through a thecium of the *Lecanora rugosella*-type (*L. crassula*): the epithecial coloration is due to minute yellowish granules inspersed among and over the tips of the paraphyses.

85. *L. expallens* Ach.—Hilltop ("Càrn Bàn") behind North

Port Sonachan, alt. 350 ft. (105 m.), on trunk of *Larix*, 11.VI.1940 (no. 1016). Fertile. Abundant.

86. *L. intricata* (Schrad.) Ach.—Open hillside near North Port Sonachan, alt. 250 ft. (76 m.), on the schistose blocks of a field wall, 9.VI.1940 (no. 979), and on the hilltop "Càrn Bàn," alt. 350 ft. (105 m.), on sloping slab of schist beneath larch trees, together with *Rhizocarpon Hochstetteri*, 11.VI.1940 (no. 1022). Fertile. New to Argyllshire.

87. *L. subrugosa* Nyl.—Shore of Loch Awe near North Port Sonachan, on trunk of *Alnus*, 8.VI.1940 (no. 958). Fertile. New to the British Isles. Previously known with certainty only from Sweden and Alsace-Lothringen (see Magnusson's remarks in his "Beiträge zur Systematik der Flechtengruppe Lecanora subfusca," in Acta Horti Gothoburg., vii (1932)). It belongs to the *L. subfusca*-group, and is characterised externally by its whitish, coarsely granulate thallus and large, thick apothecia with dark red-brown discs and heavily crenulate margins. It approaches most nearly to *L. subfuscata* H. Magn., differing from that species in the more granulate, paler thallus, thick apothecia with coarse crenulation of the margin, and presence of abundant calcium oxalate crystals in the medulla. Magnusson's key (*loc. cit.*) is the only critical and reliable treatment of this difficult group. The microscopic characters of the Argyll specimen are as follows: medulla of thallus crammed with large, colourless calcium oxalate crystals; thalline margin of apothecia corticate, the cortex 20–30 μ thick, gelatinised, ± paraplectenchymatic, sordid dark yellowish (decolorised by KHO after emission of a yellow solution); inner part of thalline margins filled with large oxalate crystals. Thecium 60–80 μ high, red-brown in upper part, not granulose (in KHO somewhat paler, yellow-brown). Spores 11–15 × 6 8 μ. Thallus KHO + yellow, probably due to the presence of atranorin, $C_{19}H_{18}O_8$.

88. *Aspicilia caesiocinerea* (Nyl.) Arn. (*Lecanora caesiocinerea* Nyl.).—Shore of Loch Awe near North Port Sonachan, on the summit of a large schistose boulder frequented by gulls, 9.VI.1940 (no. 993). Fertile. Associated with *Physcia caesia*; both of these are nitrophilous species.

89. *A. lacustris* (With.) Th. Fr. (*Lecanora lacustris* Nyl.).—Shore of Loch Awe near North Port Sonachan, forming a zone on boulders of the shore at and slightly above normal water level, 6.VI.1940 (no. 925), and 9.VI.1940 (no. 988). Fertile. A species characteristic of the margins of fresh waters in places subject to periodical inundation.

90. *Parmularia muralis* (Schreb.) B. de Lesd. (*Lecanora muralis* Schaer.).—Shore of Loch Awe near North Port Sonachan, on a small boulder slightly above the highest water level, 10.VI.1940 (no. 997). Fertile.

91. *Placopsis gelida* (L.) Nyl. (*Lecanora gelida* Ach.).—Roadside at North Port Sonachan, on a stone gatepost, 4.VI.1940 (no. 910), sterile; open hillside near North Port Sonachan, alt. 250 ft. (76 m.), on the schistose blocks of a field wall, 9.VI.1940 (no. 970), fertile; on a small boulder in a moraine on the open hillside nearby, 10.VI.1940 (no. 1010), sterile. I have found this to be a markedly oceanic species. No. 1010 is the f. *neglecta* (Degel.) M. Lamb, **comb. nov.** (*Lecanora gelida* f. *neglecta* Degel. in Acta Horti Gothoburg., xii, p. 125 (1937)), characterised by the elevated, subglobose soredia; it has not been recorded previously from the British Isles.

92. *Ochrolechia parella* (L.) Mass. (*Lecanora parella* Ach.), v. *tumidula* (Pers.) Arn.—Shore of Loch Awe near North Port Sonachan, on trunk of *Acer pseudoplatanus*, associated with *Ramalina calicaris*, 9.VI.1940 (no. 987). Fertile. New to Argyllshire; the only previous British record for this corticolous variety was from Essex, Epping Forest (Crombie in Trans. Essex Field Club, iv, p. 64 (1885), there erroneously given as "*tumida*").

93. *O. tartarea* (L.) Mass. (*Lecanora tartarea Ach.*).—Shore of Loch Awe near North Port Sonachan, on trunk of *Larix*, 5.VI.1940 (no. 915), and open hillside near North Port Sonachan, alt. 250 ft. (76 m.), on the schistose blocks of a field wall, 9.VI.1940 (no. 973). Fertile.

94. *Haematomma ventosum* (L.) Mass.—Open hillside near North Port Sonachan, alt. 250 ft. (76 m.), on a boulder in a pasture field, 15.VI.1940 (no. 1063). Fertile. Medulla KHO + intense yellow, therefore the typical form of the species (v. *typicum* Degel.).

Parmeliaceae.

95. *Parmelia* (*Hypogymnia*) *alpicola* Th. Fr.—Summit of Ben Cruachan, alt. 3689 ft. (1125 m.), on a granite boulder, 12.VI.1940 (no. 1039). Sterile. New to Argyllshire. Hillmann's combination for this species, *P. nigrita* (Fw.) Hillm., is based on the name of a form, and should not replace Th. Fries's epithet "*alpicola*," the first specific name.

96. *P. physodes* (L.) Ach.—Hilltop ("Càrn Bàn") behind North Port Sonachan, alt. 350 ft. (105 m.), on trunk of *Larix*, 11.VI.1940 (no. 1015), fertile; open hillside near North Port Sonachan, alt. 350 ft. (105 m.), on a mossy boulder at the outskirts of a wood, 15.VI.1940 (no. 1058), sterile; open hillside nearby, alt. 250 ft.

(76 m.), on schistose blocks of a field wall, 9.VI.1940 (no. 977), sterile. Nos. 1015 and 1058 are the v. *labrosa* Ach., while no. 977 is the f. *vittatoides* Mer.

97. *P.* (*Menegazzia*) *pertusa* (Schrank) Schaer.—Shore of Loch Awe near North Port Sonachan, on trunk of *Fraxinus*, 6.VI.1940 (no. 922), and on trunk of *Alnus* nearby, 6.VI.1940 (no. 924). Sterile. Both cortex and medulla KHO + yellow, but medulla only Pd + orange-red, due to the presence of stictic acid, which is probably identical with the "Menegazziasäure" of Zopf (see Asahina's remarks in Acta Phytochim., viii, p. 60 (1934)).

98. *P.* (*Euparmelia*) *caperata* (L.) Ach.—Shore of Loch Awe near North Port Sonachan, on trunk of *Alnus*, 10.VI.1940 (no. 996). Sterile. The v. *cylisphora* Ach.—*P. caperata* does not seem to be at all common here, as it is in the south of Britain; this was the only specimen seen by me.

99. *P. crinita* Ach. (*P. proboscidea* Tayl.).—Shore of Loch Awe near North Port Sonachan, on a shady outcrop of schistose rock in the mixed wood, 6.VI.1940 (no. 930). Sterile.

100. *P. fuliginosa* (Fr.) Nyl.—Roadside at North Port Sonachan, on a stone gatepost, 4.VI.1940 (no. 913). Sterile.

Var. *laetevirens* (Fw.) Nyl.—Roadside by North Port Sonachan, near the shore of the lake, on trunk of *Fraxinus*, 8.VI.1940 (no. 950). Sterile.

101. *P. furfuracea* (L.) Ach. (*Evernia furfuracea* Mann).—Hilltop ("Càrn Bàn") behind North Port Sonachan, alt. 350 ft. (105 m.), on trunk of *Larix*, 11.VI.1940 (no. 1017). Sterile. It is the v. *olivetorina* (Zopf) Zahlbr., giving a red reaction of the medulla with $CaCl_2O_2$ (olivetoric acid, $C_{16}H_{32}O_8$).

102. *P. laevigata* (Sm.) Ach.—Shore of Loch Awe near North Port Sonachan, on trunk of *Alnus*, 6.VI.1940 (no. 921). Sterile.

103. *P. olivacea* Nyl.—Shore of Loch Awe at North Port Sonachan, on trunk of *Alnus*, 5.VI.1940 (no. 914). Fertile. New to Argyllshire. A northern species which is rather uncommon in the British Isles. Degelius, in his paper on the lichens of southern Lapland in Ark. f. Bot., XXVA, no. 1 (1932), has on p. 14 a photograph of a *Betula tortuosa*-wood in the Regio subalpina of Åsele Lappmark, showing this *Parmelia* in abundance on the trunks of the trees.

104. *P. sulcata* Tayl.—Shore of Loch Awe near North Port Sonachan, on trunk of *Alnus*, 8.VI.1940 (no. 956). Sterile.

105. *P. trichotera* Hue. ("*P. perlata*" in A. L. Sm. Monogr., at any rate pr.p.).—Shore of Loch Awe near North Port Sonachan, on trunk of *Alnus*, 6.VI.1940 (no. 920). Sterile.

[*P. omphalodes* and *P. saxatilis* were most abundant around the shore of Loch Awe, occurring on both trees and rocks.]

106. *Cetraria chlorophylla* (Willd.) Vain.—Hilltop ("Càrn Bàn") behind North Port Sonachan, alt. 350 ft. (105 m.), on trunk of *Larix*, 11.VI.1940 (no. 1018). Sterile. New to Argyllshire.

107. *C. fahlunensis* (L.) Vain.—Summit of Ben Cruachan, alt. 3689 ft. (1125 m.), on granite boulder, 12.VI.1940 (no. 1033). Fertile.

108. *C. glauca* (L.) Ach.—Shore of Loch Awe near North Port Sonachan, on trunk of *Alnus*, 6.VI.1940 (no. 919). Sterile. Seen also in many other places.

109. *C. islandica* (L.) Ach.—Summit of Ben Cruachan, alt. 3689 ft. (1125 m.), among mosses between granite boulders, 12.VI.1940 (no. 1048). Sterile.

Usneaceae.

110. *Evernia prunastri* (L.) Ach.—Shore of Loch Awe near North Port Sonachan, on trunk of *Alnus*, 8.VI.1940 (no. 953). Sterile. The f. *sorediifera* Ach.

111. *Alectoria jubata* (L.) Ach., var. *prolixa* Ach.—Hilltop ("Càrn Bàn") behind North Port Sonachan, alt. 350 ft. (105 m.), on trunk of *Larix*, 11.VI.1940 (no. 1020). Sterile. The lighter parts of the thallus, the soralia, and the medulla stain vermilion-red with paraphenylenediamine, as stated by Asahina in Journ. Jap. Bot., xii, p. 689 (1936).

112. *A. pubescens* (L.) Howe jr. (*Parmelia pubescens* Vain.).—Summit of Ben Cruachan, alt. 3689 ft. (1125 m.), on granite boulders, 12.VI.1940 (no. 1036). Sterile. Degelius has shown in Nytt Mag. f. Naturvidensk., lxxviii, p. 285 (1938), that this species belongs to a special section of *Alectoria*, sect. *Subparmelia* Degel.

113. *Ramalina calicaris* (L.) Fr. Shore of Loch Awe near North Port Sonachan, on trunk of *Acer pseudoplatanus*, 9.VI.1940 (no. 986), and hilltop ("Càrn Bàn") behind North Port Sonachan, alt. 350 ft. (105 m.), on trunk of *Larix*, 11.VI.1940 (no. 1019). Fertile.

114. *R. farinacea* Ach.—Shore of Loch Awe near North Port Sonachan, on trunk of *Alnus*, 8.VI.1940 (no. 952). Sterile. New to Argyllshire.

115. *R. fraxinea* (L.) Ach.—Shore of Loch Awe near North Port Sonachan, on trunk of *Alnus*, 10.VI.1940 (no. 1002). Sterile.

116. *Usnea* sp.—Shore of Loch Awe near North Port Sonachan, on trunk of *Alnus*, 8.VI.1940 (no. 954). Sterile. It seems to approach *U. comosa* (Ach.) Vain. in many respects, but the agree-

ment is not complete, and, furthermore, I doubt whether the material is homogeneous.

Caloplacaceae.

117. *Protoblastenia rupestris* (Scop.) Zahlbr. (*Placodium rupestre* Branth and Rostr.).—Open hillside above Kilchrenan, alt. 500 ft. (150 m.), on metamorphic limestone, 7.VI.1940 (no. 934 pr.p.). Fertile.

Buelliaceae.

118. *Buellia spuria* (Schaer.) Anzi.—Open hillside near North Port Sonachan, alt. 250 ft. (76 m.), on a boulder in a pasture field, occurring chiefly on quartzose veins in the stone, 15.VI.1940 (no. 1061). Fertile. New to Argyllshire.

119. *Rinodina confragosa* (Ach.) Kbr.—Shore of Loch Awe near North Port Sonachan, on rocks above the highest water level, 15.VI.1940 (no. 1068). Fertile. New to Argyllshire. Abundant in this one place, forming small patches on the surface of the rock.

Physciaceae.

120. *Physcia caesia* (Hoffm.) Hampe.—Shore of Loch Awe near North Port Sonachan, on the summit of a large schistose boulder frequented by gulls, 9.VI.1940 (no. 992). Sterile. An extremely nitrophilous species, like *Aspicilia caesiocinerea*, by which it was accompanied.

121. *P. tenella* Bitter (*P. hispida* pr.p. in A. L. Sm. Monogr.).—Shore of Loch Awe near North Port Sonachan, on trunk of *Alnus*, 8.VI.1940 (no. 957). Fertile.

LITERATURE CITED.

Crombie, J. M., 1870: Lichens Britannici, etc.

Degelius, G. N., 1932: Zur Flechtenflora des südlichsten Lapplands (Åsele Lappmark). I. Strauch- und Laubflechten. Ark. f. Bot., xxva, no. 1.

——, 1935: Das Ozeanische Element der Strauch- und Laubflechtenflora von Skandinavien. Acta Phytogeogr. Suecica, vii.

——, 1939: Die Flechten von Norra Skaftön. Uppsala Univ. Årsskr., no. 11.

Dickson, J., 1785–1801: Fasciculus Plantarum Cryptogamicarum Britanniae.

Hooker, W. J., 1821: Flora Scotica.

——, 1831: Supplement to English Botany.

——, 1844: The English Flora of Sir James Edward Smith, v, part i.

Leighton, W. A., 1879: The Lichen-Flora of Great Britain, Ireland, and the Channel Islands, ed. 3.

Lightfoot, J., 1777: Flora Scotica.

Macmillan, H., 1875: The Rare Lichens of Glencroe. Trans. Bot. Soc. Edin., xii, p. 289.

Santesson, R., 1939: Über die Zonationsverhältnisse der lakustrinen Flechten einiger Seen im Anebodagebiet. Medd. Lunds Univ. Limnol. Instit., no. 1.

Sibbald, R., 1684: Scotia Illustrata.

Smith, Annie Lorrain, 1911: A Monograph of the British Lichens. Part II.

——, 1918: A Monograph of the British Lichens, ed. 2. Part I.

——, 1926: A Monograph of the British Lichens, ed. 2. Part II.

Smith, J. E., and Sowerby, J., 1790–1814: English Botany.

Stirton, J., 1874: New British Lichens. Grevillea, iii, p. 33.

——, 1877: New or Rare Lichens. Scottish Naturalist, iv. p. 27.

Watson, W., 1925: The Bryophytes and Lichens of Arctic-Alpine Vegetation. Journ. Ecol., xiii, p. 1.

——, 1930: Lichenological Notes. V. Journ. Bot., lxviii, p. 265.

——, 1932: Lichenological Notes. VI. Journ. Bot., lxx, p. 67.

——, 1933: Lichenological Notes. VII. Journ. Bot., lxxi, p. 314.

——, 1935: Lichenological Notes. VIII. Journ. Bot., lxxiii, p. 149.

——, 1935: Notes on Lichens, mainly from Orkney, in the Herbarium of the Royal Botanic Garden, Edinburgh. Trans. Bot. Soc. Edin., xxxi, p. 505.

——, 1942: Notes on Lichens in the Herbarium of the Royal Botanic Garden, Edinburgh. III. Trans. Bot. Soc. Edin., xxxiii, p. 183.

THE FAGACEAE OF THAILAND AND THEIR GEOGRAPHICAL DISTRIBUTION. By E. C. BARNETT, D.Sc.

(Read 18th June 1942.)

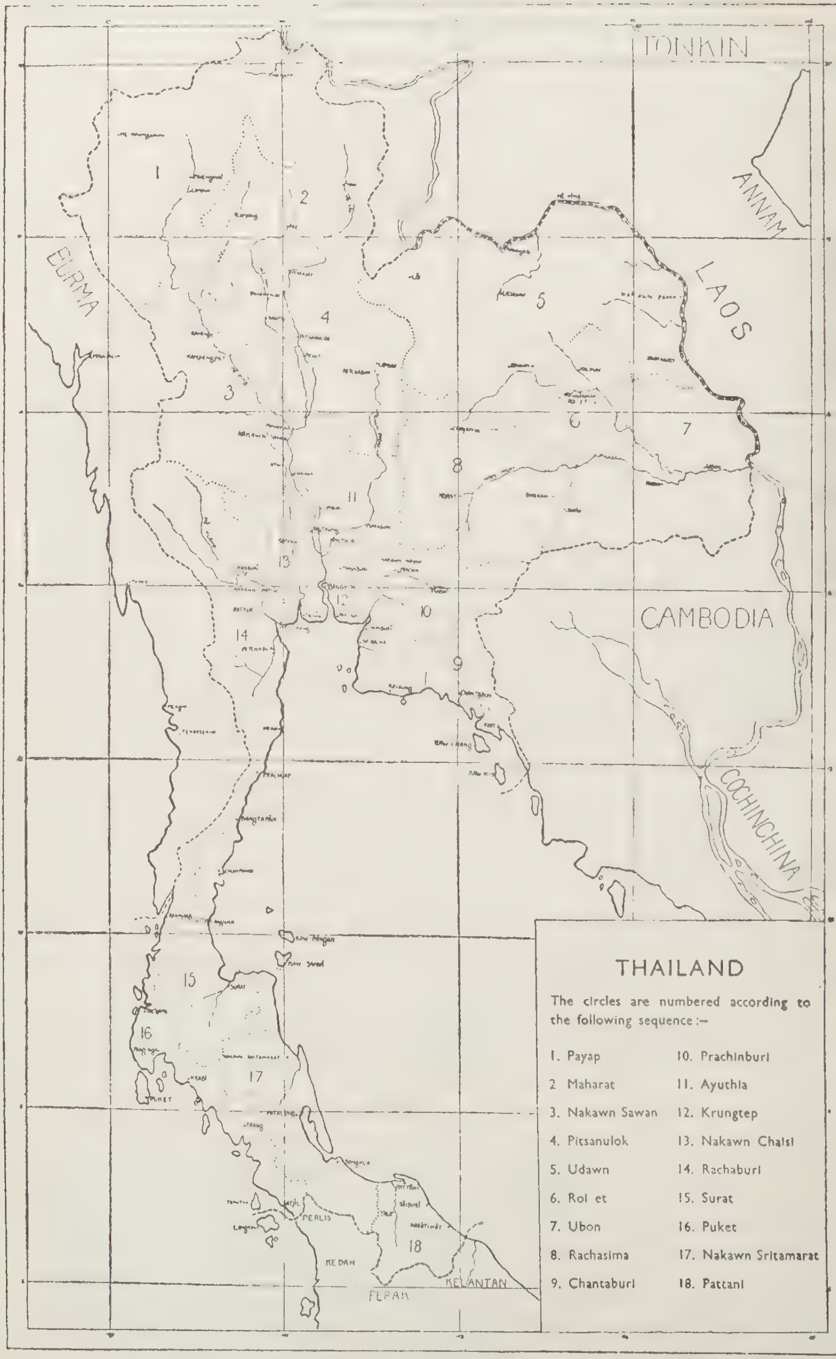
INTRODUCTION.

For political purposes Thailand is divided into eighteen districts known as circles, the boundaries of which are shown in the accompanying Map, the circles being numbered from north to south. I have included in circle 16 that part of the Langkawi group of islands which lie south of the political boundary of Thailand. In doing so I follow the plan adopted by Craib in Florae Siamensis Enumeratio, where he writes: "The inclusion of this comparatively small extra-territorial area appears advisable owing to the similarity of its flora to that of the islands north of the boundary and almost necessary on account of the lack of precision in so many of the records from the group of islands."

While the eighteen circles form a convenient basis for a preliminary statement of distribution they are by no means necessarily distinct floristically. For comparative purposes, however, four main areas may be recognised, viz. Northern, Eastern, Southern, and Peninsular Thailand. The Northern region, including circles 1–4, is mountainous. The mountains are covered with forests, but as yet it is not possible to make full use of the timber as communications are not well developed. The Eastern area, circles 5–8, is occupied by the Plateau of Korat with an average altitude of 600 feet. The Southern area, circles 9–13, extending to the Gulf of Siam, is a great alluvial plain, rice being the principal product. The Peninsular area, circles 14–18, is traversed by a continuation of the granitic range which separates Thailand from Burma.

THE FAMILY FAGACEAE.

L. C. Richard (1808) in his Analyse du Fruit separated from the old family Amentaceae those genera in which the ovules are suspended in the ovary and constituted them as a new family to which he gave the name Cupuliferae. The genera concerned are Quercus (Tourn.) Linn., Corylus (Tourn.) Linn., Carpinus Linn., Castanea (Tourn.) Linn., and Fagus (Tourn.) Linn. In his Prodromus,


TONKIN
ANNAM
BURMA
LAOS
CAMBODIA
COCHINCHINA
PERLIS
KEDAH
PERAK
KELANTAN
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
THAILAND
The circles are numbered according to the following sequence:–
1. Payap
2 Maharat
3. Nakawn Sawan
4. Pitsanulok
5. Udawn
6. Roi et
7. Ubon
8. Rachasima
9. Chantaburi
10. Prachinburi
11. Ayuthia
12. Krungtep
13. Nakawn Chaisi
14. Rachaburi
15. Surat
16. Puket
17. Nakawn Sritamarat
18. Pattani

xvi (1864), De Candolle removed Corylus and Carpinus and placed these two genera in the family Corylaceae. In the Genera Plantarum, Bentham and Hooker (1880) treated the Cupuliferae in a rather wider sense, and used the name to include three tribes: (1) Betuleae, (2) Coryleae, (3) Quercineae. The genera Quercus, Castanopsis, Castanea, and Fagus constituted the tribe Quercineae, which thus became equivalent to the Cupuliferae of De Candolle. Engler and Prantl in Pflanzenfamilien, iii (1894), treat the tribe Quercineae as a family, using the name Fagaceae. In his Contributions to the Flora of Siam, Craib (1912) accepts this restricted view but employs the earlier name Cupuliferae. Since this name was not recommended for conservation at the Sixth International Botanical Congress, the name Fagaceae is here used as conforming to the rule for family names. As now understood, the family includes six genera—Quercus, Lithocarpus, Castanopsis, Castanea, Fagus and Nothofagus. The first three are represented in Thailand, Castanea, Fagus, and Nothofagus having not so far been recorded from the country although they are known from other parts of Asia.

Owing to present restrictions upon printing it is not proposed to give full descriptions of all the Thai species of Fagaceae. Analytical Keys, however, have been drawn up. These have been made as comprehensive as possible, and it is hoped they will serve for the ready identification of the species.

KEY TO THE THAILAND GENERA OF FAGACEAE.

A. Stigmas covering the flat or recurved upper surface of the styles or capitate on them; male spikes pendulous, simple; stamens variable in number, most commonly six, anthers usually large; leaves usually serrate, dentate or lobed, seldom entire . . . 1. QUERCUS Linn.

AA. Stigmas forming terminal pores on the erect or divergent styles; male spikes erect, simple or panicled; stamens usually twelve, anthers small; leaves entire, serrate, dentate or lobed.

  B. Glans one per cupule; cupule cup-shaped or saucer-shaped or enclosing the glans, symmetrical, scales imbricate or lamellate, sometimes reduced to faint ridges; leaves entire, rarely serrate or lobed . . . . 2. LITHOCARPUS Blume

  BB. Glans 1–4 per cupule; cupule enclosing the glans, often splitting irregularly, usually with spines or tubercles, occasionally with undulate rings, often oblique; leaves entire or serrate 3. CASTANOPSIS Spach

THE GENUS QUERCUS.

Deciduous or evergreen trees or shrubs. Leaves serrate, dentate or lobed, very rarely entire, very variable in form and size even within the species. Male flowers solitary or in clusters of 1–3 in pendulous catkins; perianth scarious, 4–6 lobed, often very irregular, especially in the Lepidobalanus section, stamens variable, usually six, anthers comparatively large, about 1–1·5 mm. long, pistillode usually absent. Female flowers singly in erect few-flowered spikes; ovary 3-celled, styles usually 3, occasionally 6, more or less recurved, stigmas capitate or the whole upper surface of the styles stigmatic. Glans ovoid, globose or turbinate, partly or almost completely enclosed by the cupule from which it is free; scales of the cupule imbricate or fused in lamellae.

The genus is divided into two sections according to the form of the cupular scales:

1. Sect. Lepidobalanus with scales of the cupule imbricate.
2. Sect. Cyclobalanopsis with scales of the cupule fused in entire or more or less denticulate lamellae.

The section Lepidobalanus is a large one, the bulk of the species being American. It is represented in Asia by some 36 species, more than half of which are endemic to China. It is entirely absent from Malaya but eight species have been recorded from Thailand. Of the occurrence of two of these, however, *Q. lanata* Smith and *Q. incana* Roxb., there is some doubt.

The section Cyclobalanopsis is purely Asiatic and is represented by some 75 species, which are more evenly distributed over a wider area in Asia than those of the former section. A few are found in Malayan regions. The largest proportion is Indo-Chinese, nearly 33 per cent. being endemic to French Indo-China. Fourteen species have been recorded from Thailand.

KEY TO THE SPECIES OF QUERCUS.

I. Sect. LEPIDOBALANUS.

A. Mature leaves large, more than 10 cm. long on the average.

B. Under surface of leaves glabrous or deciduously pubescent, not tomentose.

C. Leaf margin serrate or setaceous or lobed; styles ligulate, stigmatic on upper surface.

D. Leaf margin serrate-lobed; glans ovoid, one-third covered by cupule, scales adpressed . . . . 1. *Q. aliena* Blume

DD. Leaf margin serrate-setaceous; glans globose-ovoid, more than half covered by the cupule, scales long, recurved 2. *Q. serrata* Thunb.

CC. Leaf margin dentate-serrate; styles erect, stigmas sub-capitate; glans globose-ovoid, more than half covered by cupule, scales long, adpressed . . . . 3. *Q. Kingiana* Craib

BB. Under surface of the leaves tomentose; styles ligulate, glans ovoid, one-third covered by cupule, scales short, adpressed.

C. Tomentum rufous, leaf margin serrate . . 4. *Q. lanata* Smith

CC. Tomentum hoary, leaf margin serrate-setaceous 5. *Q. incana* Roxb.

AA. Mature leaves small, usually not more than 10 cm. long.

B. Under surface of the leaves tomentose or deciduously pubescent; styles ligulate recurved.

C. Leaves tomentose, margin serrate, lateral nerves straight to margin; glans ovoid, depressed, *c.* one-third covered by the cupule . . . . . . 6. *Q. Franchetii* Skan

CC. Leaves deciduously pubescent, margin entire or spinose-toothed, lateral nerves forking short of the margin; glans globose or globose-ovoid, *c.* one-third covered by the cupule 7. *Q. semecarpifolia* Smith

BB. Under surface of the leaves deciduously pubescent; styles erect, stigmas sub-capitate; glans globose-ovoid, more than half covered by the cupule . . 3. *Q. Kingiana* Craib (shrubby form)

BBB. Under surface of the leaves glabrous, margin sharply serrate or setaceous . . . . . . 8. *Q. setulosa* Hick. & A. Cam.

2. Sect. CYCLOBALANOPSIS.

A. Glans as broad or broader than long, styles short, stigmas capitate or sub-capitate.

B. Glans hemispheric-conic, apex not depressed, scar of glans small 9. *Q. Brandisiana* Kurz

BB. Glans globose-hemispheric or much flattened, apex more or less depressed, scar large.

C. Mature glans glabrous.

D. Leaves at maturity tomentose or pubescent.

E. Leaves wide, ovate, coriaceous, tomentose 10. *Q. Helferiana* A. DC.

EE. Leaves lanceolate, chartaceous, pubescent 11. *Q. Kerrii* Craib var. *pubescens* Barnett *

DD. Leaves at maturity glabrous or with flocculent remains of pubescence.

E. Glans hemispheric-globose, cupule saucer-shaped narrowed to base, lamellae distinct, crenulate 12. *Q. lineata* Blume var. *Hildebrandii* King

EE. Glans much flattened, cupule patelliform, base flat, lamellae close-pressed, denticulate . . . 11. *Q. Kerrii* Craib

CC. Mature glans pubescent.

D. Leaves chartaceous, lateral nerves slender, curving up distinctly short of margin . . . . . 13. *Q. vestita* Rehd. & Wils.

DD. Leaves coriaceous, lateral nerves stout, curving very close to margin . . . . 14. *Q. Rex* Hemsley

AA. Glans ovoid or globose-ovoid, usually considerably longer than broad; styles ligulate, stigmatic on upper surface or long, slender, with wide recurved apical stigmas.

B. Styles ligulate, cupule covering half or more of the ripe glans.

C. Glans ovoid, two-thirds covered by cupule, upper lamellae entire; midrib of leaf keeled on upper surface . . 15. *Q. oidocarpa* Korth.

CC. Glans ovoid or globose-ovoid, one-half or more covered by cupule, upper lamellae toothed; midrib of leaf sunk above 16. *Q. lenticellata* Barnett

BB. Styles long, slender, stigmas wide recurved, cupule covering less than half glans.

C. Glans narrowly ovoid, glabrous, cupule narrowed to base pubescent or puberulous but not tomentose.

D. Glans oblique; lamellae of cupule with stout entire margins; leaves long-petiolate . . . 17. *Q. wangsaiensis* Barnett

DD. Glans symmetrical, lamellae erose-dentate; leaves almost sessile . . . . 18. *Q. glabricupula* Barnett

CC. Glans globose-ovoid or widely ovoid, pubescent or glabrous, cupule truncate at base, tomentose at least when young.

D. Young cupule turbinate, deep tawny silky tomentose, covering the glans except for the projecting umbo and styles.

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* *Q. Kerrii* Craib var. *pubescens* Barnett. A planta typica foliis oblongo-lanceolatis acuminatis marginibus a medio apicem versus serratis subtus pubescentibus differt.

E. Mature cupule saucer-shaped, covering less than half glans; leaves ovate-lanceolate or oval-lanceolate, 7–25 cm. long 19. *Q. semiserrata* Roxb.

EE. Mature cupule probably turbinate; leaves ovate, 6–9 cm. long . . . . 20. *Q. Ramsbottomi* A. Cam.

DD. Young cupule not turbinate, pale tawny tomentose, whole apex of glans exposed . . . . . 21. *Q. longistyla* Barnett

There remains the incompletely known species *Q. doichangensis* Hick. & A. Cam., the exact position of which is not clear. It was described from immature material and was given as probably belonging to the Lepidobalanus section. Later, however (Les Chênes, Monogr. Gen. Quercus, 1934), Camus suggested that it belongs to the Cyclobalanopsis section.

THE GENUS LITHOCARPUS.

Trees usually evergreen. Leaves usually entire, rarely serrate. Male and female flowers in erect simple or panicled spikes, separate or female below, male above, occasionally mixed. Male flowers singly or in clusters of three or more with one or more small bracts; perianth cup-shaped, usually 6-lobed; stamens usually 12, very occasionally fewer or more, filaments long, slender, anthers very small, about 0·5 mm. diameter; pistillode usually large and villous. Female flowers singly or in clusters of three, occasionally five, bracts small; perianth smaller than in male flower; ovary inferior, 3-celled, styles usually three, cylindric, erect or spreading, stigma a terminal pore; each flower surrounded by an involucre of imbricate or annular bracts. Glans ovoid, globose or turbinate, partly or completely enclosed by the cupule; cupular scales imbricate or fused in lamellae or reduced to fine ridges.

The genus is entirely Asiatic, extending from the Himalayas, China, and Japan southwards through the Malay Peninsula as far as Borneo. Some 190 species have been recorded, excluding those of the Philippine Islands. Seventy-two species (38 per cent.) are known from French Indo-China, over half of them being endemic. The Malayan region is almost as rich in species, while 15 per cent. occur in China and only 5 per cent. in India. Thirty-one species, including four whose identification is a little doubtful, have been recorded from Thailand.

The genus may be divided into five sections, all of which, except Corylopasania, confined to French Indo-China, are represented in Thailand.

Key to the Sections of Lithocarpus.

Cupule scutelliform, saucer- or cup-shaped; scales distinct imbricate or more or less arranged in rings but not fused to form lamellae . . 1. Pasania

Cupule as above but the scales fused to form entire or denticulate lamellae 2. Cyclobalanus

Cupule covering the glans completely except for the umbo and styles, or leaving apex exposed but not fused with it except at the base 3. Chlamydobalanus

Cupule usually thick, covering the glans completely or leaving the apex exposed, fused with it completely . . . . . . 4. Synaedrys

Cupule covering and considerably longer than the glans . . 5. Corylopasania

Key to the Species of Lithocarpus.

1. Sect. Pasania.

A. Cupular scales long, recurved.

B. Glans ovoid, cupule covering only the base. Leaves coriaceous, glabrous . . . . . 1. *L. Scortechinii* (King) A. Cam.

BB. Glans hemispheric, cupule covering whole or more than half.

C. Glans pubescent, leaves papery.

D. Leaves glabrous, cupular scales over 1 cm. long, slender, hooked . . . . . 2. *L. longispinus* Barnett

DD. Twigs and leaves velvety pubescent, cupular scales subulate, less than 0·5 cm. long, hooked 3. *L. lappaceus* (Roxb.) Rehd.

CC. Glans glabrous, leaves coriaceous.

D. Twigs glabrous, leaves lanceolate, very shortly pubescent beneath, scar of glans plane or convex 4. *L. recurvatus* Barnett

DD. Twigs densely tomentose, leaves oblanceolate or obovate, densely pubescent beneath, scar of glans concave 5. *L. Garrettianus* (Craib) A. Cam.

AA. Cupular scales short, adpressed or with free tips.

B. Cupule patelliform covering base only of the ovoid-conic glans, leaves chartaceous, long caudate . . 6. *L. Curtisii* (King) A. Cam.

BB. Cupule saucer- or cup-shaped, covering less than half the glans.

C. Glans hemispheric-conic.

D. Fruits singly, shortly pedicellate, scales with free tips recurved, glans reddish, glabrous . . 7. *L. sundaicus* (Blume) Rehd.

DD. Fruits in clusters, scales adpressed, more or less arranged in rings.

E. Fruits in crowded clusters, sessile, glans pubescent, styles long.

F. Cupule and glans deep tawny pubescent, styles divergent from the base, scar slightly concave 8. *L. Wallichianus* (Lindl.) Rehd.

FF. Cupule and glans hoary pubescent, styles erect, divergent at apex, scar deeply concave . 9. *L. Thomsoni* (Miq.) Rehd.

EE. Fruits in distant clusters, pedicellate, glans glabrous, styles short . . . . 10. *L. polystachyus* (Wall.) Rehd.

CC. Glans hemispheric, more or less depressed, not conic.

D. Leaves coriaceous, acuminate, not caudate, glabrous, lateral nerves about 12 pairs, curving up short of the margin, becoming very faint; tips of cupular scales not feee 11. *L. spicatus* (Smith) Rehd. & Wils. var. *gracilipes* A. DC.

DD. Leaves chartaceous, caudate, closely pubescent below, lateral nerves curving close to the margin clear, *c.* 14 pairs, cupular scales with tips free . . . 12. *L. intermedius* Barnett

CCC. Glans ovoid.

D. Cupules often crowded but not fused, rusty pubescent, scales not umbonate.

E. Glans glabrous shining, leaves very large, 20–40 cm. long, bud scales long, persistent . . 13. *L. Falconeri* (Kurz) Rehd.

EE. Glans reddish-granular pubescent, leaves average 15 cm. long . . . . . . 14. *L. rufescens* Barnett

DD. Cupules in groups of 3–5 more or less fused, scales umbonate.

E. Leaves large, widely ovate or obovate or panduriform, petiole short.

F. Twigs and leaves densely and softly pale tawny tomentose 15. *L. Lindleyanus* (Wall.) A. Cam.

FF. Twigs and leaves glabrous 11. *L. spicatus* (Smith) Rehd. & Wils. var. *brevipetiolata* A. DC.

EE. Leaves lanceolate or ovate-lanceolate, petiole long.

F. Twigs softly pale tawny tomentose, leaves glabrous or puberulous below, cupules, *c.* 1 cm. deep and wide 16. *L. Harmandii* (Hick. & A. Cam.) A. Cam.

FF. Twigs glabrous or very scantily puberulous, leaves glabrous, cupule less than 1 cm. wide, 0·5 cm. deep 11. *L. spicatus* (Smith) Rehd. & Wils. var. *microcalyx* A. DC.

BBB. Cupule deep, covering the whole or at least two-thirds of the glans.

C. Wall of cupule thin, apices of the scales free and more or less recurved.

D. Glans glabrous, scar plane; leaves long caudate, glabrous 17. *L. fenestratus* (Roxb.) Rehd.

DD. Glans pubescent, scar decidedly convex; leaves acute, not caudate, pubescent beneath 18. *L. dealbatus* (Hook. fil. & Th.) Rehd.

CC. Wall of cupule thick, scales close adpressed, tips not free, in somewhat indistinct lamellae towards the base.

Fruit globose or globose-conic, scar convex occupying one-third to one-half of the pubescent glans 19. *L. Craibianus* Barnett

2. Sect. CYCLOBALANUS.

A. Cupule sessile.

B. Cupule thin, distinctly wider than the hemispheric glans 20. *L. Eichleri* (Wenzig) A. Cam.

BB. Cupule thick.

C. Leaves thinly coriaceous, small, narrowly lanceolate or oblanceolate, apex obtuse, lateral nerves slender; glans glabrous, very shortly apiculate, cupular lamellae regular, entire 21. *L. omalokos* (Korth.) Rehd.

CC. Leaves thickly coriaceous, widely ovate apex abruptly caudate, lateral nerves stout; cupular lamellae irregular, obscurely dentate, glans pubescent, umbo long cylindric 22. *L. cyclophorus* (Endl.) A. Cam.

AA. Cupule shortly pedicellate or tapered to a stalk-like base.

B. Cupule thick, lamellae thick, rounded; glans turbinate 23. *L. Clementianus* (King) A. Cam.

BB. Cupule thin, distinctly wider than the hemispheric glans 20. *L. Eichleri* (Wenzig) A. Cam.

AAA. Cupules distinctly stalked.

B. Leaves coriaceous, oblong-lanceolate or obovate-oblong.

C. Twigs slender, black; cupule solitary, pedicel long, stout, annulated; glans hemispheric-apiculate 24. *L. Reinwardtii* (Korth.) A. Cam.

CC. Twigs stout; cupules in groups when young, later singly by abortion, pedicel short, stout; glans hemispheric-depressed 25. *L. Cantleyanus* (King) Rehd.

BB. Leaves thinly coriaceous or parchment-like, abruptly caudate; cupules solitary, pedicel slender; glans hemispheric-conic 26. *L. sootepensis* (Craib) A. Cam.

3. Sect. CHLAMYDOBALANUS.

A. Cupule covering the glans except for the umbo and styles.

B. Cupule bearing obscure rings, scales not visible.

C. Leaves chartaceous, lateral nerves about 8 pairs arched; glans hoary or pale tawny silky pubescent
27. *L. encleisacarpus* (Korth.) A. Cam.
CC. Leaves coriaceous, lateral nerves *c*. 11 pairs, straight; glans rufous silky pubescent . . . 28. *L. pattaniensis* Barnett
BB. Young cupule bearing prominent scales, mature cupule with scales still visible, arranged in obscure rings
29. *L. Blumeanus* (Korth.) Rehd.
AA. Whole top of the glans exposed.
B. Cupules usually singly, mouth thin, scar of glans concave; leaves chartaceous, lateral nerves arched
27. *L. encleisacarpus* (Korth.) A. Cam. var. *aperta* King
BB. Cupules clustered, mouth thick, scar of glans wide convex; leaves coriaceous, lateral nerves straight . . 30. *L. aggregatus* Barnett

4. Sect. SYNAEDRYS
Fruit turbinate, distinctly flattened at apex, glans fused with the cupule except for the exposed flat top . 31. *L. truncatus* (King) Rehd. & Wils.

Doubtful Species.—Four species, the available material of which is immature, are included with some degree of doubt. These are: *L. Clementianus* (King) A. Cam., *L. Eichleri* (Wenzig) A. Cam., and *L. Reinwardtii* (Korth.) A. Cam., belonging to the Cyclobalanus section, and *L. Blumeanus* (Korth.) Rehd., belonging to the Chlamydobalanus section.

THE GENUS CASTANOPSIS.

Trees, rarely shrubs, deciduous or evergreen. Leaves entire, serrate or lobed. Flowers in erect spikes, male and female separate or occasionally mixed, singly or in clusters with one or more small bracts. Male flowers with perianth of six segments, free or connate; stamens usually 12, occasionally fewer, filaments slender, anthers small, about 0·5 mm. in diameter, very occasionally about 1 mm.; pistillode large, villous or several villous scales. Female flower with perianth of six segments smaller than male; ovary 3-celled, styles usually 3, occasionally 4, cylindric, stigma a terminal pore; each flower or each cluster surrounded by an involucre of bracts. Ripe cupule covering completely the one to four glans (except in *C. calathiformis* and *C. fissa*, where the cupule is cup-shaped) often splitting irregularly, more or less covered by whorls of simple or branched spines or tubercles, or with entire ridges, in which case the cupule is decidedly oblique.

The genus is entirely Asiatic, some 104 species having been recorded, excluding those of the Philippine Islands. French Indo-China possesses some 48 species, three-fourths of which are endemic. The species are, on the whole, more evenly distributed than those of Lithocarpus, China having 24 per cent., the Malayan regions 30 per cent., and India 7 per cent. of the total number. Fifteen species have been recorded from Thailand. There is some doubt about *C. nephelioides* King, the available material being immature.

KEY TO THE SPECIES OF CASTANOPSIS.

A. Cupule not covering the glans completely. Leaves large, coriaceous, serrate-lobed, nerves bold.
B. Cupule a deep cup covering two-thirds or more of the glans, bearing undulate rings . . . . . 1. *C. fissa* (Champ.) Rehd. & Wils.
BB. Cupule a shallow cup covering half or less of the glans, bearing scales more or less fused in rings but with tips free 2. *C. calathiformis* (Skan) Rehd. & Wils.
AA. Cupule covering one to three glans but not fused with them.
B. Leaves serrate or serrate-lobed.
C. Leaves large, coriaceous, nerves bold; cupule globose, covered by simple or branched slender spines. . 3. *C. indica* A. DC.
CC. Leaves small, serrate at the apex only, nerves slender; cupule obliquely ovoid, with rings of short, tubercle-like spines 4. *C. acuminatissima* (Blume) Rehd.
BB. Leaves entire.
C. Fruits more or less covered by slender, branched or simple spines.
D. Fruits large, over 2 cm. diameter.
E. Leaves coriaceous, lateral nerves impressed above, spines brown.
F. Lateral nerves bold below, transverse nerves prominent, cupule thick, glans solitary, with pale greenish scar occupying about half its height . 5. *C. diversifolia* King
FF. Lateral nerves slender, transverse nerves almost invisible; cupule thin, glans solitary, with basal plane-concave scar . . . . . . 6. *C. costata* A. DC.
EE. Leaves papery; spines black with pale tips, glans 1–3 7. *C. argyrophylla* King
DD. Fruits small, about 1·5 cm. diameter 8. *C. tribuloides* (Smith) A. DC.
CC. Fruits with stout branching greyish pubescent spines.
D. Leaves coriaceous.
E. Spines stout, shortly stellately branched, glans usually one, scar large, about half or more height of glans 9. *C. armata* Smith
EE. Spines stout with spreading branches, glans 1–3, scar basal, convex . . . . 10. *C. purpurea* Barnett
DD. Leaves papery.
E. Spines very variable, branches long or short, glans solitary, scar occupying about two-thirds of height 11. *C. argentea* A. DC.
CCC. Fruits with stout or small tubercles or oblique rings.
D. Tubercles stout, covering wall except for bare patches between lobes of horizontally lengthened fruit . 12. *C. Pierrei* Hance
DD. Tubercles very short and distant in undulate rings.
E. Fruit large, lengthened horizontally, sessile, when mature more or less lobed, glans 1–3, scar occupying about one-third of the height . 3. *C. inermis* (Lindl.) Barnett n. comb.
EE. Fruit turbinate, pedicellate, scar occupying whole surface of the solitary glans except the apical disc 14. *C. piriformis* Hick. & A. Cam.
DDD. Tubercles absent, fruit wall with entire or denticulate oblique rings, scar of glans basal 15. *C. lanceaefolia* (Roxb.) Hick. & A. Cam.
AAA. Cupule covering completely the glans and fused with it. Cupule oblique, covered, except on the flattened inner side, with short angular tubercles . . . . 16. *C. nephelioides* King

DISTRIBUTION.

In the foregoing analysis sixty-nine species have been included, but, as already stated, there is some degree of doubt about the occurrence in Thailand of seven of them. The several species are divided among the genera as follows:—

Quercus with 22 species, of which 5 are endemic.
Lithocarpus with 31 species, of which 7 are endemic.
Castanopsis with 16 species, of which 1 is endemic.

So far as our present knowledge goes 405 species belonging to these three genera have been recorded from Asia, excluding the species endemic to the Philippine Islands. Of these, 111 belong to Quercus, 190 to Lithocarpus, and 104 to Castanopsis. The Thai representation amounts to no more than 17 per cent. of the total, but it is of interest that the proportion of species is approximately the same for the three genera, the percentages being 19·8, 16·3, and 15·4 respectively.

Throughout their range of distribution, the members of the Fagaceae with which we are here concerned are mainly forest trees, although under certain ecological conditions some of them form scrub. In Thailand they occur most commonly in the hilly districts, but a few species have been found at altitudes below 50 m. As is to be expected, no member of the family has been recorded from the alluvial plains in circles 11, 12, and 13 (Ayuthia, Krungtep, and Nakawn Chaisi), nor is there any record from the small circle 6 (Roi Et). This may be accounted for by the fact that little collecting has been done in this district compared with some of the other circles, *e.g.* Payap, from which the largest number of species has been recorded. Dr. Kerr tells me that the topographic and climatic conditions are very similar to those of Payap in the adjoining district of Maharat, and he feels sure that when this circle has been more fully explored its flora will prove equally rich.

While certain features in the distribution of species throughout Thailand become apparent when all the available data are taken into account, it is necessary to consider briefly the geographical relationships of this relatively small country with Eastern Asia as a whole. So far as the distribution of the Asiatic Fagaceae is concerned, four major regions have to be considered:

1. *The Indo-Burmese region* including the Indian Himalayan areas, Eastern Bengal, Assam and Upper Burma.
2. *The Chinese region* including China, Korea, Formosa, Hainan and Japan.

3. *The French Indo-Chinese region.*
4. *The Malayan region* including Lower Burma, the Malay Peninsula and the Malay Islands.

The floras of these regions are, of course, not wholly unrelated, and species from all of them occur in Thailand. Many are common to the first three regions, and from a survey of the Thai species alone it is not possible to determine the original centre of distribution of those which are spread over a wide area. On the other hand, the Malayan species are most clearly restricted in their distribution. The geographical relationships of the three genera under review will be considered more fully, however, following a statement of the distributional data relating to Thailand itself.

Table I shows the range of the species of Quercus in the four areas into which the eighteen circles of Thailand have been grouped for purposes of floristic comparisons. The areas are: Northern (circles 1–4), Eastern (circles 5–8), Southern (circles 9–13), and Peninsular (circles 14–18). Arranged in this way these larger areas seem to provide a better basis for broad comparisons than the several circles themselves.

The largest number of species of Quercus has been recorded from the Northern area, at least fourteen occurring in circle 1 (Payap) in the extreme north of the country. Of the section Lepidobalanus all the species are Northern or Eastern, while five belonging to the section Cyclobalanopsis occur in the Southern and Peninsular areas together. These general features are a reflection of the distribution of the species outside Thailand. Of the seventeen which are not endemic twelve or thirteen are known from the Indo-Burmese region and nine from French Indo-China, where *Q. setulosa* seems to have its main centre. The connections of the genus as found in Thailand are clearly with these two regions.

Although a few species occur also in the Chinese region, the only one found solely in China is *Q. Franchetii*, which is confined to Yunnan and circle 1 (Payap). It may not, however, belong to a true Chinese element, as it is undoubtedly very closely related to the Indo-Chinese species *Q. lanata* and *Q. incana*. Schottky makes the suggestion that it may be a form of *Q. lanata* modified by the drier climate of the Indo-Chinese plateaux.

While the section Lepidobalanus is absent from the whole of the Malayan region, six species belonging to the Cyclobalanopsis section are found in Lower Burma or Malaya. Only one, however, *Q. oidocarpa*, is truly Malayan, extending northwards as far as Peninsular Thailand (circle 17, Nakawn Sritamarat); the others are

TABLE I.

THE GENUS QUERCUS.

	Northern.	Eastern.	Southern.	Peninsular.	Indo-Burmese.	Chinese.	Indo-China.	Malayan.
Circles	1–4.	5–8.	9–13.	14–18.				
Sect. 1. LEPIDOBALANUS.								
aliena	×	×	–	–	×	×	×	–
serrata	–	×	–	–	×	×	×	–
Kingiana	×	–	–	–	×	–	–	–
lanata	?	–	–	–	×	–	×	–
incana	?	–	–	–	×	–	–	–
Franchetii	×	–	–	–	–	×	–	–
semecarpifolia	×	–	–	–	×	×	–	–
setulosa	–	×	–	–	–	–	×	–
Sect. 2. CYCLOBALANOPSIS.								
Brandisiana	×	–	–	–	×	–	–	–
Helferiana	×	–	–	–	×	×	×	×
Kerrii	×	×	–	–	?	–	×	–
lineata	×	–	–	–	×	–	–	×
vestita	×	–	–	–	×	–	×	×
Rex	×	–	–	–	×	×	×	–
oidocarpa	–	–	–	×	–	–	–	×
†*lenticellata*	×	–	–	–	–	–	–	–
†*wangsaiensis*	–	–	–	×	–	–	–	–
†*glabricupula*	×	–	–	–	–	–	–	–
semiserrata	×	×	×	–	×	–	×	×
Ramsbottomi	–	–	–	×	–	–	–	×
†*longistyla*	–	×	–	×	–	–	–	–
†*doichangensis*	×	–	–	–	–	–	–	–

Species marked † are endemic.

northern species which have migrated southwards into Malay. The Thai species of Quercus thus constitute an essentially northern assemblage in the flora of the country, 66 per cent. occurring in the Northern area, and it is not without interest that three of the five endemic species are known only from circle 1 (Payap).

Thirty-one species of Lithocarpus, seven of which are endemic, have been recorded. The data given in Table II indicate, in contrast to Quercus, that the largest number of species, twenty or about 68 per cent. of the total, is found in the Peninsular circles and only fourteen or 45 per cent. in the Northern area. In the Pasania section, however, the species are more evenly shared between

TABLE II.

THE GENUS LITHOCARPUS.

	Northern.	Eastern.	Southern.	Peninsular.	Indo-Burmese.	Chinese.	Indo-China.	Malayan.
Circles	1–4.	5–8.	9–13.	14–18.				
Sect. 1. PASANIA.								
Scortechinii	–	–	–	×	–	–	–	×
†*longispinus*	–	–	–	×	–	–	–	–
lappaceus	×	–	×	×	×	–	–	×
†*recurvatus*	×	–	–	–	–	–	–	–
Garrettianus	×	–	–	×	–	–	×	–
Curtisii	–	–	–	×	–	–	–	×
sundaicus	–	–	–	×	–	–	–	×
Wallichianus	–	–	–	×	–	–	–	×
Thomsoni	×	×	×	–	×	–	×	–
polystachyus	–	–	×	?	×	–	×	×
spicatus	×	×	–	×	×	×	×	×
intermedius	×	–	–	×	×	–	–	–
Falconeri	–	–	–	×	–	–	–	×
†*rufescens*	–	–	–	×	–	–	–	–
Lindleyanus	×	–	–	–	×	–	×	–
Harmandii	×	×	×	–	–	–	×	–
fenestratus	×	–	–	–	×	?	×	–
dealbatus	×	–	–	–	×	×	×	–
†*Craibianus*	×	–	–	–	–	–	–	–
Sect. 2. CYCLOBALANUS.								
Omalokos	–	–	–	×	–	–	–	×
cyclophorus	–	–	–	×	–	–	–	×
†*sootepensis*	×	–	–	×	–	–	–	–
Cantleyanus	–	–	×	×	–	–	–	×
**Clementianus*	–	–	–	×	–	–	–	×
**Eichleri*	–	–	–	×	–	–	–	×
**Reinwardtii*	–	–	×	×	–	–	×	×
Sect. 3. CHLAMYDOBALANUS.								
encleisacarpus	–	–	–	×	–	–	–	×
†*pattaniensis*	–	–	–	×	–	–	–	–
†*aggregatus*	×	–	–	–	–	–	–	–
**Blumeanus*	–	–	–	×	–	–	–	×
Sect. 4. SYNAEDRYS.								
truncatus	×	–	×	–	×	–	×	–

Species marked † are endemic. * Identification doubtful.

Northern and Peninsular areas, and only in this section is there any noteworthy representation in Eastern and Southern circles. The sections Cyclobalanus and Chlamydobalanus are noteworthy in being essentially Peninsular, the outstanding exceptions being the endemic species *L. sootepensis* Craib and *L. aggregatus* Barnett, the latter known only from Payap. Beyond Thailand these two sections are almost exclusively Malayan (*L. Reinwardtii* occurs also in French Indo-China), and it seems clear that the Thai representatives are immigrants from the south. On the other hand, species belonging to the Pasania and Synaedrys sections are more widely distributed, especially in French Indo-China and Indo-Burmese regions. Eight of the fifteen non-endemic species of the section Pasania occur in India or Upper Burma, six of them being known also from Indo-China. Most of them are fairly widely distributed in Thailand, but only three—*L. lappaceus*, *L. polystachyus*, and *L. spicatus* -penetrate southwards to the Peninsular area and beyond into Malaya. The representation of Chinese species is meagre, the only examples being *L. spicatus* and *L. dealbatus*, both in the Pasania section, and they occur also beyond China. The Thai species of Lithocarpus thus fall into two fairly distinct geographical groups, one being clearly derived from the south, the other having connections with regions lying to the north and east. Of the seven endemic species, four are found in the Northern and three in the Peninsular area.

As shown in Table III, the distribution of the sixteen species of Castanopsis in Thailand is, on the whole, more even than in the case of Quercus and Lithocarpus, although the Northern and Peninsular areas, each with 50 per cent., possess the majority of species. This greater uniformity characterises also the distribution of the species in the surrounding regions, eight occurring in Malaya and Indo-China, and seven each in China and the Indo-Burmese region. Four species—*C. costata*, *C. argentea*, *C. inermis*, and *C. nephelioides*—belong to Malaya, and appear in Thailand only in the Peninsular area. The remaining four Malayan species have a wide distribution elsewhere. Two species occur only in Indo-China. These are *C. Pierrei* and *C. piriformis*, both closely allied to the typical Malayan *C. inermis*, and it may be noted they are absent from the Northern part of Thailand. A Chinese and Indo-Chinese species is *C. fissa*, while *C. armata* and *C. lanceaefolia* are Indo-Burmese. The Thai species of Castanopsis appear to have been derived, therefore, from several floristic elements, all the neighbouring regions having contributed to the representation of the genus in Thailand. The only

TABLE III.

THE GENUS CASTANOPSIS.

	Northern.	Eastern.	Southern.	Peninsular.	Indo-Burmese.	Chinese.	Indo-China.	Malayan.
Circles	1–4.	5–8.	9–13.	14–18.				
indica	×	×	–	–	×	×	×	–
calathiformis	×	–	–	–	×	×	×	×
fissa	×	–	–	–	–	×	×	–
accuminatissima	×	×	×	–	–	×	×	×
diversifolia	×	–	–	×	×	×	–	–
costata	–	–	–	×	–	–	–	×
argyrophylla	×	–	×	×	×	×	×	×
tribuloides	×	–	–	–	×	×	×	×
armata	–	–	×	–	×	–	–	–
†*purpurea*	×	×	–	×	–	–	–	–
argentea	–	–	–	×	–	–	–	×
Pierrei	–	–	×	×	–	–	×	–
inermis	–	–	–	×	–	–	–	×
piriformis	–	×	×	×	–	–	×	–
lanceaefolia	–	–	×	–	×	–	–	–
**nephelioides*	–	–	–	×	–	–	–	×

Species marked † is endemic. * Identification doubtful.

endemic species is *C. purpurea*, recorded from both Northern and Eastern areas, and most closely allied to *C. armata*.

The author is indebted to the Carnegie Trust for a grant towards the cost of publication.

SUMMARY.

The family Fagaceae is represented in Thailand by three genera: Quercus Linn., Lithocarpus Blume, and Castanopsis Spach. Sixty-nine species have been recorded, of which thirteen or almost 19 per cent. are endemic.

From the data at present available it appears that the largest number of species, about 55 per cent. of the total, occurs in the Northern area. The Peninsular area comes next with about 48 per cent., while the Eastern and Southern areas have only 19 per cent. and 20 per cent. respectively.

The non-endemic species are related to the floras of four main Asiatic regions: Indo-Burmese, Chinese, Indo-Chinese and Malayan. As many species are common to more than one of these regions, it

is not possible to determine exactly the origin of all the Thai species.

The closest relationship appears to be with the Indo-Burmese flora. This is illustrated by the distribution of the majority of the species of Quercus, the Pasania section of Lithocarpus, and by a few species of Castanopsis. For the family as a whole, about 50 per cent. of the non-endemic species probably belong to the Indo-Burmese element.

A distinct Malayan element is evident, notably in the sections Cyclobalanus and Chlamydobalanus of the genus Lithocarpus, while some species of Castanopsis are also clearly Malayan. The element is found, as might be expected, almost exclusively in the Peninsular area of Thailand and represents about 32 per cent. of the non-endemic species.

Affinities with the Chinese and Indo-Chinese floras are more difficult to determine, but an essentially Chinese element appears to be but poorly represented. A definite Indo-Chinese element, at present comprising five or six species restricted to this region, is likely to prove stronger when the Eastern and Southern areas of Thailand are more fully explored.

Of the endemic species, five belong to Quercus, seven to Lithocarpus, and one to Castanopsis. Three of the endemic species of Quercus and three belonging to Lithocarpus are known only in the northern mountainous part of the country.

CUSCUTA GALLS. By R. J. D. GRAHAM, M.A., D.Sc.

(Read 21st May 1942.)

The European species of Cuscuta are all annual, and wither after the seeds have ripened. *Cuscuta reflexa* is a perennial species from India cultivated for teaching purposes under glass in St. Andrews. Though flowering in autumn of its first season and setting seed it continues to live through the winter, renewing its growth during several years. In the Central Provinces of India *Cuscuta reflexa* grows commonly on *Acacia arabica* and *Zizyphus Jujuba.* In cultivation in this country it readily attacks a large variety of hosts, amongst which are *Begonia* spp., *Gesnera zebrina. Hibiscus Rosa-sinensis, Hedera Helix, Lonicera sempervirens, Murraya exotica, Pelargonium* spp., *Rondeletia odorata.*

Propagation of the parasite is easy once it has been raised from seed. Actively growing apical portions removed and placed on suitable hosts rapidly attach themselves, and the parasite spreads to the stem by the further growth of these filaments. When the filament approaches the stem of the host the filament becomes slightly swollen and wart-like suckers develop, the portion resembling a caterpillar ready to attach itself to the stem. This precocious formation of haustoria on the portions approaching the host has not so far been recorded. The host responds to the attack in all the species named above by enlargement of the stem. In particular the enlargement in *Hibiscus* takes the form of swellings like galls as much as one inch in diameter. The parasite frequently branches at the points of contact, each point of attachment forming a centre from which the parasite spreads to fresh areas of the host. In autumn active growth of the parasite ceases and the filaments wither between the swollen points of attachment. In the following spring these swollen areas are the starting-points for renewed activity. In consequence they form a convenient method for distribution of the parasite should there be a demand for it. Stewart (1) mentions the regeneration of *Cuscuta reflexa* from the haustoria, but the formation of galls is not recorded. These galls consist of the tissues of both host and parasite, thus resembling the Mistletoe gall on *Tilia* mentioned by Adam (2).

In *Hibiscus* where, as previously stated, the swellings are exceptional in size, it was noted that growth of the parasite in the following growing season rarely took place—certainly from less than 2 per cent. of the swellings. Investigation of the swellings in April showed that they consisted mainly of paranchyma covered with cork surrounding the haustoria of the parasite. Terminal leafy portions of twigs bearing swellings were placed in a tropical propagating frame to encourage growth of the parasite. Chlorophyll developed in the swelling and the lenticels proliferated freely, and, instead of the parasite, roots developed from the swelling. From this evidence it is obvious that these swellings are callus tissue developed from the host and it may be possible that the abundant production of callus tissue has deprived the parasite of its food supply, thus leading to its death from starvation. The elimination of the parasite by the activity of the host is, so far as is known, unrecorded. The possibility of the use of the *Hibiscus* galls caused by *Cuscuta* as a source of growth-promoting substances is being investigated.

REFERENCES.

(1) STEWART, L. B.: Exhibit of Haustoria of *Cuscuta reflexa* showing Vegetative Growth. Proc. Bot. Soc. Edin., xxx (1930), p. xxii.
(2) ADAM, R. M.: Exhibit of Mistletoe as a Parasite on Lime. *Ibid.*, p. x.

TRANSACTIONS

OF THE

BOTANICAL SOCIETY OF EDINBURGH

SESSION CVII

PRESIDENTIAL ADDRESS. BY R. J. D. GRAHAM, M.A., D.Sc.

(Read 25th February 1943.)

It was in 1843 that Robert Graham, Professor of Botany in the University of Edinburgh, held for the last time the office of President of the Botanical Society of Edinburgh. His name will always be remembered with gratitude for the wise foresight he showed in deciding that the Royal Botanic Garden should be moved to its present site. It was in 1917, the last year of the Four Years War—may the omen be propitious!—that Robert Alexander Robertson, my predecessor as Head of the Department of Botany in the University of St. Andrews, delivered from the Presidential Chair an address on "the need for an adequate knowledge of chemistry in the solution of biological problems." It will be my endeavour, in this address, to follow the more illustrious bearer of my name by making a contribution, however small, to the Garden and to combine this with demonstrating the wisdom that my predecessor in St. Andrews displayed when he stressed the need of an adequate knowledge of chemistry for the solution of biological problems. If, in this combination of aims, I succeed in re-affirming the prophetic foresight of the late Laurence Baxter Stewart, my fellow-worker on vegetative propagation, I shall deem the occasion thrice blessed. My endeavour, then, is to review in the light of recent work on phytohormones the contributions of L. B. Stewart which made the Royal Botanic Garden so famous for pioneer work on vegetative propagation and earned for the exhibition of these methods in July 1924 the title of "botanical wizardry" (33). MacLeay * in his

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* Kenneth N. G. MacLeay: Paper read before Society on 21st May 1942.

paper "on practical applications of Hormone action in the rooting of cuttings" has paved the way for such an extended review. In reviewing Stewart's contribution in the light of our present knowledge of phytohormones his work may conveniently be examined under the headings of selection of material for propagation, the preparation and insertion of the material in the medium used for regeneration and the results attained.

In the selection of material for stem cuttings Stewart favoured the terminal portions of the current season's growth (1) (15). The selected portion was removed by a clean cut made through a node and no leaves were removed (39). It was van der Lek (24) who, in calling attention to plants in which root initials are present and others in which new initials have to be formed, showed the influence of a bud on root development. Especially, in cuttings where root initials do not exist, he showed how the presence of a bud strongly promoted root formation. This led to the first suggestion that the developing bud formed hormones. Went (46) in his work on Acalypha cuttings showed that the bud markedly and leaves to a less extent influence the formation of roots on stem cuttings. In 1931 isolated Acalypha leaves were rooted in Edinburgh (14). It was in 1934 that Went (47), using Pea seedlings, established the connection between the bud and auxin. It is interesting to note that the bud exercises a double function, for, even when a cutting is supplied with an external source of auxin, a bud is still found to be necessary for root formation. MacLeay notes that Stewart's severance of material at the node, beside the leaf with its bud, secures the hormone supply which each contributes. How well one remembers Stewart's remark: "If you remove the bud, laddie, you stop the engine." Rogenhofer (31) established a quantative relationship between bud and callus formation, development being inversely proportional to the distance between bud and cut, and directly proportional to the number of buds. The importance of the bud in Stewart's eyes comes out again in making stem cuttings of Asparagus, when Stewart (39, p. 36) always selected for propagation the basal portion where, as he said, there were buds to develop. The more rapid rooting of *Pyracantha angustifolia* (15, p. 31), following the removal of the branch spines, may also be connected with the activity of accessory buds above the spines. Ivy and Schizophragma (39, p. 35), where "breast wood," lateral branches from the climbing wood, is selected in preference to portions of stem with developed climbing roots, suggest definite cases where auxin supply has been exhausted in the production of the climbing roots. These references indicate that Stewart knew the importance of bud and leaf in promoting regeneration. One might be tempted to pursue the same line of argument to explain Stewart's selection of side branches in plants with large piths such as Ash, large-leaved Rhododendrons and others. The reason he gave was that the branch had a smaller pith with less area to heal and that there was less danger of decay. Thimann (44), however, has shown that there is an inherent quantitative difference in responsiveness in root production in seedling trees between lateral branches and the terminal shoot. Lateral branches root more readily than the terminal shoot, auxin conditions being the same. May it not be as Stewart suggested that there is a relatively greater proportion of active cells in the branch than in the main stem coupled with shorter internodes and a greater supply of plastic material. Stewart would have supported Thimann's view of the inherent difference between branch and main shoot as he noted the different behaviour of lateral branch cuttings compared with cuttings of the terminal portion of *Gardenia amoena* (38). Much interest centres round the fact that side branches of *Gardenia amoena* when used as cuttings yield low-growing, leafy plants, devoid of spines and floriferous, whereas terminal cuttings and the parent plant have never flowered in cultivation in Edinburgh. Dostal in Circaea has shown that flowering is opposed by auxin supply, and Delisle (5) established that the much branched habit in the nana forms of Aster were low in auxin production. This may furnish an explanation of the flowering of the side branch cuttings of Gardenia and other plants, but Hitchcock and Zimmermann (18) on the contrary found that watering the soil with high concentrations of organic acids speeded up the development of flower buds in tobacco. While considering the inherent difference between branch cuttings and terminal cuttings, it is to be noted that Stewart (40) insisted that a whorled branch with dorsiventral symmetry from such plants as Araucaria, Picea, Gardenia, Napoleona always remained a side branch, and, when used as a cutting, gave dwarf or creeping plants with dorsiventral symmetry. The formation of a new leader on the parent plant, when the apical bud of such plants was injured or on a plant raised from a dorsiventral branch, Stewart held to be a growth from a "plastic bud." The plastic bud was one in Stewart's opinion capable of giving either a lateral branch if a leader be present, or a leader if the plastic bud develop after the influence of the leader has been removed. Any lateral bud which had commenced to grow under the influence of a leader continued as a lateral bud, giving characteristic dorsiventral growth, and never changed into growth with radial symmetry. The development of lenticels interested Stewart much (39, p. 35), especially as in old stem cuttings, roots frequently exit from them. Lugovroy (25) states that trees and shrubs characterised by a particularly open type of lenticel were readily propagated by stem cuttings.

Each plant has a set time at which most rapid rooting results. This time, at which cuttings should be taken, was very important in Stewart's mind. Stem cuttings of beech are best taken when the last two leaves of the season are unfolding. Azaleas have an especially limited season during which they may be rapidly propagated. Stewart's idea (39, p. 37) was to place on record the best months for propagating plants. First a survey was completed of one species of each genus grown in the Garden, and then an endeavour was made to run through each Family, species by species. Charts were prepared for the plants examined showing the results of taking cuttings from each plant each month of the year (10, pp. 457–459) (11, pp. 109–111). Stewart's idea was that the best ratio between cells capable of response and cell reserve necessary for growth is to be found at the close of the current season of growth of any particular plant. It is interesting to note that Thimann and Delisle (44A) found the winter season the best for taking cuttings of Conifers, and Stewart's calendar contains the names of plants which rooted best in the winter months, showing that some factor other than the ratio of cell to reserves must be taken into account. A further factor is apparent in the experiments with Escallonia (11) made in Edinburgh where cuttings from certain plants rooted more quickly than cuttings from others. Stewart attributed this to the aspect in which the plants grew, but Thimann and Delisle have shown that the response may vary from clone to clone. Stewart would readily have subscribed to the finding that the response is individual to the plant within the species. Still another factor is the age of the plant. Iljin (19), Vekhov and Iljin (45), Thimann and Delisle (44A) all find that the age of the plant from which cuttings are taken has a marked effect on the percentage strike, the younger plant always being preferable as a source of propagative wood. This may be the case in seedling trees, but it cannot be a universal phenomenon, unless the senescent effect is removed by vegetative propagation as horticultural forms with double flowers or with variegated leaves must have been grown from cuttings from time immemorial.

Despite the fact that nodal severance generally gives the best and quickest development of roots, this position of severance corresponding with the supply of auxin from bud and leaf as pointed out by MacLeay, in Clematis quicker rooting was obtained by severing the cutting an inch below the node. In the propagation of Dahlia and Pelargonium, Woycicki and Terpenski (49) obtained similar results with internodal severance of cuttings. It is to be noted that etiolated Clematis cuttings rooted well at the node, so the success with internodal cuttings may indicate a lack of auxin at the node, or as MacLeay suggests etiolation may increase the permeability of the tissues to auxin transport. Dorfmuller (6) shows that the action of light on the stem inhibited both root formation and was, also, an obstacle to the action of auxin on the cell wall. Smith (34) in her investigation of Clematis showed etiolation brought about internal changes, such as the reduction of reserve starch, and confirmed Reid's work (30) on Camphor. Preparatory to taking cuttings of Camphor, Reid showed that blanching of the twigs yielded quicker results in rooting, this being attributed to reduction in the Camphor content and reversion of lignification in the mechanical tissues of the pericycle. This feature, which has lately attracted renewed attention, has been named dedifferentiation by Bloch (3). The speedier rooting of Camphor (2) may equally be due to the removal of the inhibiting action of light, particularly white light, on the number of roots developed on a cutting. The rooting of stem cuttings of Apples has always been looked upon as a difficult operation. The secret of success which Stewart held was never to allow the cutting to wilt. The portions to be used as cuttings were severed under water and kept with their ends in water until they were inserted in the rooting medium.

Turning to the preparation of the cutting Stewart insisted on a straight cut as giving the minimum area for healing. He frowned on the common practice of removal of the basal leaves as this increased the area to be healed. As Stewart put it, a cutting will get rid of the leaves it does not want. Rappaport (28) in his experiments on Skimmia confirms the correctness of Stewart's faith in the retention of leaves. He found, when treating cuttings with heteroauxin, that the number of leaves affected the rooting of both the treated cuttings and also of the control. The use of synthetic growth substances has been employed by Zimmermann and Hitchcock (50), Rappaport (29) and many others, but the results of the experiments carried out by MacLeay on Forsythia and Lycium together with his discussion bear out much of what this address claims for Stewart. The advantages in the use of growth substances are that the treated cuttings root more rapidly, give a greater percentage of strike, and the plants raised have a better developed root system.

In making leaf cuttings of Begonia, Bertolonia, Phyllagnathis and others the number of plants raised from one leaf can be increased by severing the veins when buds develop as the base of each cut portion. This obviously indicates that the polar transport of auxin in the leaf is interrupted by the cut. It is more difficult to explain the rooting and growth in thickness of inverted cuttings of Willow (16) if basal transport of auxin is constant. The increasing growth as shown by the annual rings suggests that a reverse transport has become established. Went (48) has discussed a similar phenomenon in Tagetes and concludes that the transport is reversed.

Sharp sand in the unheated propagating case and coconut fibre in the tropical pit were Stewart's choice as rooting media (1, p. 458). In the heated case, with moisture rising from the tanks below, sand became sodden and formed an ideal substratum for algae. Regeneration was recognised as a growth process and aeration was therefore essential. Woyacki and Terpenski (49) state that the best results are obtained with rather coarse sand with 50–75 per cent. water-holding capacity. Stewart, following Small (32), increased acidity in the rooting medium by using Acetic Acid or peat water, other workers at Edinburgh (35) altered the reaction by the use of mineral acids. MacLeay suggests that the success with vinegar as an aid to rooting may be explicable as Acetic Acid forms part of the molecule of certain growth-promoting substances. Goehde (8) states his preference as acid sand at pH6. Harig (17), Kakesita (21), and Prevot (27) showed that increase of Carbon Dioxide in the medium increased rooting. Stewart (40, p. 83) used Potassium Permanganate not only for fighting grey mould in his rooting medium but claimed a value for it when applied to the base of cuttings. Lastly in the tropical cases, with moisture ascending from the tanks below, more than one attempt was made to electrically charge the ascending moisture and thus imitate the effect of electrically charged rain-drops.

Stewart kept the atmosphere of his cases at saturation point either by ascending moisture in the heated cases or repeated sprinkling with water in the unheated ones. La Rue (23) has shown that on leaves growth hormones are the cause of intumescences and that cell growth is more prominent in humid and stagnant chambers, and this may in part explain Stewart's practice. By experiment it was found that thermostatically controlled temperature (9) gave better results. Du Buy (7) found 25° C. the optimum for auxin production, there being a falling away both above and below this temperature. May it not be that the hot-water treatment (1, p. 454) of resinous cuttings, particularly *Pinus sylvestris*, owes its success in part to heat just as much as to getting rid of resin as Stewart thought. An extreme instance of the use of sun heat was seen in the sun frame (1, p. 459), in which Stewart rooted double Whin and *Erinacea pungens* which is supposed to require 15 months, but in the sun frame roots in 21–30 days. A day of cloud would bring despair as the absence of sun retarded rooting. Under such conditions a uniform temperature was impossible, the soil temperature may rise to an intense degree but fluctuates. It may be that the direct sun rays have a stimulating effect other than heat. An experiment with Vita glass was carried out (13). Measurements of ultra violet light established the fact that more ultra violet rays than with ordinary glass reached the experimental material even though the light passed through Vita glass on the roof as well as on the sashes. The results were inconclusive except that the expense was not justified.

Many an argument arose with Stewart over shading his propagating cases from strong light. Stewart admitted, that in root cuttings, in raising Acanthus from a portion of an internode without a bud and particularly when he rooted Roscoff Brocoli curd (12), the first sign of success was the greening of the material. Navez (26) and others have found that auxin production falls off unless plants are exposed to light. Thimann (43) has cleared up the problem by pointing out that the conflicting views can be explained on the ground that some cuttings store auxin and others do not. In cuttings without auxin storage, and this includes most leafy cuttings, light is required for its production and therefore for rooting.

Stewart found that the paring of the callus promoted rooting in the propagation of certain plants which developed large callus. Such over-sized callus Stewart likened to a malignant growth and he stated that paring the callus brought the parent cells into control again (39, p. 33). Such a callus must be formed by a cutting rich in auxin, and as the roots do not come from the callus the root growth may be due to a reduction of auxin supply. An alternative explanation may be suggested from the results of Cooper (4) and of Jackson (20), both of whom gained success in rooting difficult material by re-treating the cutting with growth substances a few weeks after the first treatment.

W. T. Swingle (42) considers the recapitulation of seedling characters, which he termed neophysis, in nucellar buds of citrus is due to chemical substances found only in association with the embryo sac. It would appear that this author is unaware of Stewart's work (39, fig. 41) on the leaflets of Zamiocalcas. In Zamiocalcas a tuber forms at the base of the leaflet, and to this tuber Stewart applied the term pro-embryo as from it a plant arises with seedling characters. Root cuttings of several plants, stem cuttings of Acanthus from a single internode (36), and the plants from the base of the severed veins of leaves (39, p. 37) all yield growths with what Stewart called juvenile characters.

Before closing it may be mentioned that C. F. Swingle (41) has omitted all reference to Stewart's work at Edinburgh, which in itself is surprising, but it is more surprising to find references to Kemp's (22) experiments with Monocotyledon leaves when the same results were recorded by Stewart and McMartin's (25A) work on Acanthus which is based on Stewart's work on the same plant.

To sum up, Stewart was a man who knew his plants—he was a man with a green thumb—who selected his material and created the external conditions which he fully recognised operated through internal responses. The Edinburgh school explained its results in terms of the response to suitable conditions of living cells supplied with plastic material and environment. The living cell is a centre of many activities, the most characteristic of which is to reproduce. This potentiality to produce new cells is inhibited as a cell develops, but so long as a cell retains its living contents, external or internal factors may remove the inhibition and the cell is activated into new growth. That one of the internal factors might be an acid pabulum was hazarded by Bailey Balfour in 1913. This acid has now been identified, but it is only one part of the mechanism, the cell will respond according to its inherent capacity. The acid may be considered the trigger which when pressed may release certain activities. The trigger is but one part of the mechanism, the result of pressure depends on the rest of the mechanism and the charge, both of which are varied in the living plant. To know that there is a trigger is one step nearer understanding the problem of regeneration.

REFERENCES.

(1) BALFOUR, I. B. (1913): Problems of propagation. Journ. Roy. Hort. Soc., 38.
(2) BLACKIE, J. J., GRAHAM, R. J. D., and STEWART, L. B. (1926): Propagation of Camphor. Kew Bulletin.
(3) BLOCH, R. (1941): Wound healing in higher plants. Bot. Rev., 7.
(4) COOPER, W. C. (1938): Effect on root formation of retreating cuttings with growth substances. Science, 87.

(5) Delisle, A. L. (1937): The influence of auxin on secondary branching in two species of Aster. Am. Journ. Bot., 24.

(6) Dorfmuller, W.: Lichtwirkung und Wuchsstoffe in ihrer Bedeutung für die Bewurzelung von Commelinaceen-Stecklingen. Jahrb. Wiss. Bot., 86.

(7) du Buy, H. G. (1933): Über Wachstum und Phototropismus von *Avena sativa*. Rec. trav. bot. neerl., 30.

(8) Goehde, H. L. (1938): The importance of correct sand for propagation. Florist's Exchange, 91.

(9) Graham, R. J. D. (1930): Thermostatische Heizung fur Vermehrungszwecke. Gartenschonheit, 10.

(10) —— (1934): The work of L. B. Stewart. Trans. Bot. Soc. Edin., 31.

(11) —— (1936): Laurence Baxter Stewart's methods of propagation at Edinburgh. Scientific Horticulture, 4.

(12) Graham, R. J. D., and Stewart, L. B. (1930): Vegetative propagation of Brocoli from heads. Trans. Bot. Soc. Edin., 30.

(13) ——, —— (1930): Experiments with Vita glass. Trans. Bot. Soc. Edin., 30.

(14) ——, —— (1931): Studies in vegetative propagation; Acalypha, Dioscorea and *Stenoglottis longifolia*. Trans. Bot. Soc. Edin., 30.

(15) ——, —— (1931): Special methods of practical utility in vegetative propagation of plants. Proc. 9th Int. Hort. Cong. London.

(16) Graham, R. J. D., Hawkins, Kate H., and the late L. B. Stewart (1934): An inverted cutting of Willow. Trans. Bot. Soc. Edin., 31.

(17) Harig, Annemarie (1931): Untersuchungen über die experimentelle Beeinflussbarkheit von Wachstunsvorgängen bei vegetativer Fortpflanzung und Regeneration. Planta, 15.

(18) Hitchcock, A. E., and Zimmermann, P. W. (1935): Absorption and movement of synthetic growth substances from soil as indicated by the response of aerial parts. Contrib. Boyce Thompson Inst., 7.

(19) Iljin, M. P. (1934): The influence of different factors on the rooting of cuttings. Trudy Prikl. Bot. Genet. i Selek. Suppl., 61.

(20) Jackson, T. H. (1938): Absorption of growth promoting substances by cuttings. Nature, 141.

(21) Kakesita, K. (1933): A contribution to the knowledge of regeneration in higher plants. Journ. Fac. Agr. Hokkaido Imp. Univ. Sapporo, 35.

(22) Kemp, E. E. (1936): Regeneration from mutilated leaves of monocotyledons. Notes Roy. Bot. Gd. Edin., 19.

(23) La Rue, C. D. (1937): Intumescences on poplar leaves. The role of plant growth hormones in their production. Am. Journ. Bot., 23.

(24) Lek, H. A. A. van der (1925): Over de wortelvorming van houtige stekken. Diss., Utrecht.

(25) Lugovoy, M. (1937): The rooting and non-rooting of tree species in connection with the anatomical structure of lenticels. Ukraine Akad. Nauk. Inst. Bot. Zhur., 15.

(25a) McMartin, A. (1933): Propagation from the leaf of Acanthus. Trans. Bot. Soc. Edin., 31.

(26) Navez, A. E. (1933): Growth promoting substance and illumination. Proc. Nat. Acad. Sc., 19.

(27) Prevot, P. C. (1933): La néoformation des bourgeons chez les végétaux. Soc. Roy. Sc. Liege, Mem. (Ser. 4), 3.

(28) Rappaport, J. (1939): De invloed van bladeren en groeistoffen op de beworteling van stekken. Nat. Tijds., 21.

(29) —— (1933): Further researches on the root formation in cuttings induced by synthetic growth substances, I. Meded. Landbouwhoogeschool Gent., 7.

(30) Reid, Oona (1923): Propagation of Camphor by stem cuttings. Trans. Bot. Soc. Edin., 28.

(31) Rogenhofer, Gabriele (1936): Wirkung von Wuchsstoffen auf die Kallusbildung bei Holzstecklingen. Akad. Wiss. Wien, Abt. I, 145.

(32) Small, J. (1923): Propagation by cuttings in acid media. Gard. Chron., Ser. 3, 73.

(33) —— (1924): Botanical wizardry or plant propagation at Edinburgh. Garden, 88.

(34) Smith, Edith P. (1924): Anatomy and propagation of Clematis. Trans. Bot. Soc. Edin., 29.

(35) —— (1928): Reaction of the medium in relation to root formation in Coleus. Trans. Bot. Soc. Edin., 30.

(36) Stewart, L. B. (1922): Notes on juvenile characters in root and stem cuttings of *Acanthus montanus*. Trans. Bot. Soc. Edin., 28.

(37) —— (1923): Propagation of difficult plants. Gard. Chron., Ser. 3, 73.

(38) —— (1924): Remarks on the morphology and propagation of *Gardenia amoena*. Trans. Bot. Soc. Edin., 29.

(39) —— (1927): Methods of propagation. Journ. Roy. Hort. Soc., 52.

(40) —— (1932): Propagation of Conifers. Rept. Conifer Conference. London.

(41) Swingle, C. F. (1940): Regeneration and vegetative propagation. Bot. Rev., 6.

(42) Swingle, W. T. (1932): Recapitulation of seedling characters by nucellar buds developing in the embryo sac of citrus. Proc. Sixth Int. Cong. Genetics, 2.

(43) Thimann, K. V. (1937): Phytohormones. Exp. Bio. Monograph, New York.

(44) —— (1941): The hormone control of plant development. Am. Nat., 75.

(44a) Thimann, K. V., and Delisle, A. L. (1942): Notes on the rooting of some Conifers from cuttings. Journ. Arnold Arb., 23.

(45) Vekhov, N. K., and Iljin, M. P. (1934): Vegetative propagation of trees and shrubs by means of summer cuttings. Trudy Prikl. Bot. Genet., i, Selek., 61.

(46) Went, F. W. (1929): On a substance causing root formation. Proc. Kon. Akad. Wetensch. Amsterdam, 32.

(47) —— (1934): On the pea test method for auxin, the plant growth hormone. Proc. Kon. Akad. Wetensch. Amsterdam, 37.

(48) —— (1941): Polarity of auxin transport in inverted Tagetes cuttings. Bot. Gaz., 103.

(49) Woycicki, S., and Terpenski, Z. (1937): Über den Enfluss der Stecklingsform and Sandfeuchtigkeit auf die Bewurzelung. Roczn. Nauk. Ogrondicz., 4.

(50) Zimmermann, P. W., and Hitchcock, A. E. (1940): Adventitious shoots and roots induced by natural influences and synthetic growth substances. Boyce Thompson Inst. Contr., 11.

THE GENUS MELAMPYRUM IN BRITAIN.

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(Read 15th October 1942.)

Melampyrum is one of a group of genera included in the suborder Rhinanthideae of the order or family Scrophularineae that are noteworthy for obtaining additional materials for growth by means of organs of attachment affixed to the roots of neighbouring plants. Other native genera are *Euphrasia* and *Rhinanthus*, and all three are distinguished by the extreme polymorphism of the species. *Melampyrum* is chiefly restricted to the northern hemisphere with a very wide range over the whole of Europe and Asia. Outside that area one species and one subspecies, both related to the common *M. pratense* L., occur in N. America. On a conservative view the number of species is about 25, but if a broader view is held, then the number may be increased to about 45. Four species are found in Britain. *M. pratense* L. in many forms is generally spread throughout the island, but is absent from many large areas. *M. silvaticum* L. is more abundant in the northern half of Britain. extending to but few districts south of the Scottish border. *M. arvense* L. and *M. cristatum* L. have their home chiefly in the east of England. Of these four species, the third and fourth are included in the section Spicata marked by the flowers being arranged in congested spike-like racemes closely invested by broad and short bracts. Subsection Arvensia with more or less conical inflorescences and plane bracts includes *M. arvense* L., and subsection Carinata includes *M. cristatum* L., with a 4-angled inflorescence with concave bracts. In section Laxiflora the flowers are in more or less distant pairs, all directed to one side, in the axils of bracts wholly leaf-like in *M. silvaticum* L., and leaf-like or the upper pairs toothed or lobed in the case of *M. pratense* L. The species are gregarious, forming communities which owe their existence in a great measure to the activities of ants. At the period when the capsules begin to liberate the seeds, extra-floral nectaries situated on various parts of the plants commence to excrete a watery saccharine fluid attractive to ants. The extra-floral nectaries in their most conspicuous form are seen as rows of black dots on the bracts of *M. arvense* L., and as indistinct shallow depressions can also be detected on the leaves and bracts of *M. pratense* L. Many observers have recorded ants engaged in the transport of the comparatively large seeds of *Melampyrum*, and it appears that these are collected for the food material afforded by the elaisomes or appendages situated at one extremity. From the seeds collected by ants arise the *Melampyrum* communities of a subsequent season. In situations unfavourable to the activities of ants, such as Sphagnum swamps, the plants occur as scattered individuals.

Key to the Species, Subspecies, Varieties, and principal Formae of Melampyrum *found in the British Isles.*

The best results will be obtained when using the key by a clear understanding of the terms used, and a few words of explanation follow. The primary leaves of a plant are the *cotyledons*, usually oblong or spathulate in form, remaining fresh and green, or more or less shrivelled, or even already fallen at the flowering period. If the cotyledons are absent, the point at which they originated is recognised by the scars at the base of the stem. Above and distant from the cotyledons, and from each other, are pairs of leaves originating at successive *nodes*, the intervening portions of stem constituting *internodes*. Branches may arise from the axils of the cotyledons and stem leaves, and may freely develop or remain more or less rudimentary. The term *cauline leaves* is applied to all pairs of leaves succeeding the cotyledons up to and including those leaves in the axils of which the uppermost pair of branches arise. Above the uppermost branches are pairs of leaves each bearing a flower in the axil. It may occur that the lowest pair or pairs of leaves above the uppermost branches are without accompanying flowers, and in that case these leaves, which are really barren bracts, are termed *intercalary leaves*. The leaves that follow with axillary flowers are *bracts*. In the case of *M. pratense* L. the intercalary leaves and the lower bracts are little different in appearance from the cauline leaves, but the upper bracts are progressively modified, becoming shorter and broader and dentate at the base, the apical bracts being frequently palmatifid with linear spreading lobes. In deciding at what point an inflorescence commences, count is made of the nodes from the base of the stem upwards, starting at the cotyledonary node. In the genus *Melampyrum*, as in related genera, owing to the intense darkening of all parts, including flowers, that follows desiccation, it is more satisfactory to study living plants rather than herbarium material, and in consequence characters appear in the key that are not apparent in dried material. This especially refers to the primary divisions of *M. pratense* L. Here it may be helpful to point out that sections 4 to 14 comprise the smaller forms of the species, plants ranging from 10 to 30 cm. in height, and that in sections 15 to 27 are included some of the most developed forms, bushy plants of from 40 to 50 cm. in height.

1. Flowers arranged in spicate racemes closely invested by broad short bracts 2
   Flowers arranged in ± distant opposite secund pairs in the axils of leaf-like bracts 3
2. Inflorescence 4-angled, bracts concave caudate imbricate *M. cristatum* L.
   Inflorescence conical bracts plane ecaudate lax . . *M. arvense* L.

M. cristatum L.

Branches many, arcuate-ascending, intercalary leaves 0–3 pairs, remote from inflorescence . . . . var. *cristatum* Beauv.
Branches few or none, obliquely-erect, intercalary leaves 0 or 1 pair contiguous to inflorescence . . . . var. *Ronnigeri* Beauv.

M. arvense L.

Cauline leaves 4–7 (10) mm. wide, inflorescence commencing at nodes 9–12 . . . . var. *arvense* Beauv.
Cauline leaves 10–17 mm. wide, inflorescence commencing at nodes 7–9 . . . . . . var. *Schinzii* C. E. Britton

3. Calyx-teeth linear-subulate, appressed, the upper pair falcate, corolla-tube straight, lower lip directed forward . *M. pratense* L.
   Calyx-teeth linear-lanceolate, equal, spreading, corolla-tube curved, lower lip deflexed . . . . . *M. silvaticum* L. 28

M. pratense L.

Plants favouring open sunny situations or partial shade. Corolla-tube white or pale yellow, helmet yellow, palate orange or yellow, lips distant. Flowers assuming a rose-purple or lilac tint prior to fading 4
Plants of shady situations, flowers not usually becoming rose-purple or lilac 15

4. Cauline leaves usually 1 pair, inflorescence commencing at nodes 2 or 3 (4) 5
   Cauline leaves 1–3 pairs, inflorescence commencing at nodes 4–5 . 9
5. Small plants (10–20 cm. in height), stems with short branches or sub-simple 6
   Medium-sized plants (20–30 cm. in height), often of lax growth . 7
6. Often of contracted habit with contiguous foliar organs, corolla usually tipped with crimson ssp. *scotianum* (Beauv.) C. E. Britton
   Lax, foliar organs distant, corolla pale or marked with crimson. ssp. *alpestre* (Brügg.) Ronn. var. *extensum* C. E. Britton
7. Diffuse, branches elongated, widely-spreading, all internodes elongated . . . . . . ssp. *meridionale* C. E. Britton
   Erect, branches not widely-spreading. 8

8. Stem-internodes *c.* 40 mm. long, branches ascending-erect, inflorescence commencing at node 3 (rarely 2 or 4).
ssp. *typicum* (Beck) O. Dahl f. *foliatum* Neum.

Stem-internodes 40–100 mm. long, branches spreading, short, inflorescence commencing at nodes (3) 4 (5).
ssp. *typicum* (Beck) O. Dahl f. *laxum* Beauv.

9. Dwarf plants usually with entire or sub-entire bracts 10

Plants usually robust, upper bracts dentate at base 13

10. Very slender plants with narrowly linear leaves and usually entire bracts 11

Less slender plants, leaves and bracts linear-lanceolate, bracts entire or the apical with two spreading teeth at base . . . 12

11. Cauline leaves 2–3 pairs, branches erect.
ssp. *paludosum* (Gaud.) Soó var. *paludosum* Gaud.

Cauline leaves 1–2 pairs branches spreading or ascending.
ssp. *paludosum* (Gaud.) Soó var. *montanum* (Johnst.) Bab.

12. 12–16 cm. in height, stems slender, well-branched; leaves and bracts linear acuminate, 10 times as long as broad.
ssp. *ericetorum* (D. Oliv.) C. E. Britton
var. *decipiens* (Beauv.) C. E. Britton
f. *confine* C. E. Britton

10–15 cm. in height, stems fairly stout, branches sometimes rudimentary, leaves linear obtuse, bracts linear-lanceolate obtuse, 6 times as long as broad . . . . ssp. *ericetorum* (D. Oliv.)
var. *propinquum* C. E. Britton

13. Branches well-developed 14

Branches ± arrested and non-flowering, rarely more than one pair developing.
ssp. *ericetorum* (D. Oliv.) C. E. Britton var. *proximum* C. E. Britton

14. Intercalary leaves 1–2 pairs, inflorescence commencing at nodes 6–7.
ssp. *ericetorum* (D. Oliv.) C. E. Britton var. *ericetorum* D. Oliv.

Intercalary leaves 0–1 pair, inflorescence commencing at node 4 (5).
ssp. *ericetorum* (D. Oliv.) var. *decipiens* (Beauv.) C. E. Britton

15. Corolla normally with tube white or pale yellow, helmet and lips yellow, palate yellow, lips contiguous 16

Corolla usually uniformly golden yellow, at times verging on orange, lips distant 26

16. Upper cauline leaves, intercalary leaves, and lower bracts broad (ovate, oval, or elliptical-lanceolate) 17

Upper cauline leaves, intercalary leaves, and lower bracts narrow (linear or linear-lanceolate) 23

17. Cauline leaves usually 1 pair 18

Cauline leaves 3–5 pairs 19

18. Leaves present at flowering-time, lower bracts ovate-lanceolate, apical bracts pectinate-dentate.
ssp. *oligocladum* (Beauv.) Soó var. *oligocladum* Beauv.

Leaves usually already fallen at flowering-time, lower bracts linear-lanceolate, apical bracts sub-hastate dentate.
ssp. *oligocladum* (Beauv.) Soó var. *britannicum* Beauv.

19. Leaves and bracts short or of medium length (50–65 mm.) . . 20

Leaves and bracts decidedly elongated (70–100 mm.).
ssp. *vulgatum* (Pers.) Ronn. var. *laurifolium* (Beauv.) C. E. Britton

20. Intercalary leaves 0 or 1 (2) pairs 21

Intercalary leaves 2–5 pairs 22

21. Apical bracts few, with short teeth.
ssp. *commutatum* (Tausch) C. E. Britton f. *ovatum* (Spenn.) Beck
Apical bracts many with elongated setaceous teeth.
ssp. *vulgatum* (Pers.) Ronn. var. *digitatum* Schur.
22. Intercalary leaves 2–4 pairs . ssp. *commutatum* (Tausch) C. E. Britton f. *pseudo-nemorosum* (Beauv.) Soó
Intercalary leaves 4–5 pairs (or more).
ssp. *commutatum* (Tausch) C. E. Britton f. *concolor* (Schönh.) C. E. Britton
23. Intercalary leaves 1–4 pairs 24
Intercalary leaves 0–2 pairs 25
24. Bracts wholly entire or apical with two small teeth at base.
ssp. *angustifrons* (Borbás) Soó var. *pseudo-silvaticum* Schur.
Bracts usually with 1–2 linear distant lobes at base.
ssp. *angustifrons* (Borbás) Soó var. *vogesiacum* Beauv.
25. Leaves usually fallen at flowering-time, lower bracts broad (6–13 mm. wide).
ssp. *vulgatum* (Pers.) Ronn. var. *devonianum* (Beauv.) C. E. Britton
Leaves present at flowering-time, lower bracts usually narrow (4–10 mm. wide) ssp. *vulgatum* (Pers.) Ronn. var. *lanceolatum* Spenn.
26. Leaves and bracts linear-lanceolate, bracts entire or apical hastate, rarely pectinate at base, inflorescence commencing at nodes 4–5.
ssp. *hians* (Druce) Beauv. var. *hians* Druce
Leaves oblong-lanceolate, bracts ovate-lanceolate, inflorescence often commencing at node 3 27
27. Bracts acuminate, apical with linear spreading lobes at base.
ssp. *hians* (Druce) Beauv. var. *amplifolium* C. E. Britton
Bracts acute, apical with four distant awl-shaped teeth at base.
ssp. *hians* (Druce) Beauv. var. *hibernicum* Druce

M. silvaticum L.

28. Foliage thin, usually rather narrow, stem-internodes 25–40 mm. long, inflorescence commencing at nodes 4–5 29
Foliage thick and fleshy, rather broad, especially bracts, inflorescence commencing at nodes 3–4 . . . ssp. *aestivale* Ronn.
29. Plant 15–30 cm. in height, branches 1–3 pairs strict or ascending, frequently all arrested and sterile.
ssp. *subsilvaticum* (Schinz et Ronn.) Soó
Plant 22–30 cm. in height, branches usually 3 pairs widely spreading or arcuate-erect, again branched and floriferous.
ssp. *subsilvaticum* (Schinz et Ronn.) Soó var. *Toddae* C. E. Britton

M. cristatum L. Sp. Pl. (1753), 605; Icones "English Botany," t. 41.

An erect, rigid puberulous annual 30–50 cm. high, with pectinate-caudate plicate bracts closely investing flowers. Stem obscurely 4-angled, branches numerous or scanty, erect-ascending, rarely arcuate, lower or all arrested. Laminae sub-sessile, lanceolate-linear entire, margins recurved, 50-90 mm. long, intercalary leaves pectinate at base, 0–1–(2) pairs. Inflorescence 3–5 cm. long, bracts purplish, cordate-ovate at base, the upper acuminate, the lower with elongated linear-lanceolate spreading or reflexed apices.

Flowers shortly pedicelled, calyx-tube 3 mm. long, anterior teeth 1·5 mm. long, triangular, posterior teeth 4 mm. long, linear subulate ciliate. Corolla 12-16 mm. long, yellow and rose, tube curved, mouth open. Capsule semi-ovate, compressed, acuminate, 10 × 4 mm., dehiscence ventral, seeds ellipsoidal, 4·5 × 2 mm., black. Flowering in June to September.

Two varieties occur: var. *cristatum* (L.) Beauv. ap. Schinz et Keller, Fl. d. Schw., 3 Aufl., ii (1914), 304. Syn.: *M. cristatum* L. s.s.; *M. cristatum* subsp. *cristatum* Ronn. ap. V N G Zürich, lv (1910), 308; *M. cristatum* var. *cristatum* sub-var. *typicum* Beauv. Mon., 462. Stem 20–50 cm. high, internodes short, 5–12 beneath inflorescence; branched from the base, branches many, ascending, elongated, the upper flowering. Cauline leaves 5–10 mm. wide, intercalary leaves 0–3 (or more) pairs, remote from inflorescence. Inflorescence 3–5 cm. long, commencing at nodes 6–11. The usual British form.

Var. *Ronnigeri* Beauv. ap. Schinz et Keller, Fl. d. Schw., 3 Aufl., ii (1914), 304. Syn.: *M. Ronnigeri* Pöverlein ap. Allg. bot. Zeitschr. (1907), 179; *M. cristatum* subsp. *Ronnigeri* (Pöverl.) Ronn. ap. V N G Zürich, lv (1910), 307. *M. cristatum* var. *cristatum* sub-var. *Ronnigeri* Beauv. Mon., 462. Stem 15–30 cm. high, internodes short or elongated, 5–7 (usually 6) beneath inflorescence, branches few or none, with or without flowers. Cauline leaves 5–8 mm. wide, intercalary leaves 0 or 1 pair, contiguous to inflorescence. Inflorescence *c.* 3 cm. long, commencing at nodes 6–8.

Oak-woods, coppices, and adjacent banks and hedge-rows in southern, eastern, and eastern-midland counties of England: S. Wilts, S. Hants, N. Essex, Herts, E. and W. Suffolk, W. Norfolk, Cambridge, Huntingdon, Bedford, Northampton, S. Lincoln, Nottingham. Var. *Ronnigeri* Beauv. has been identified by Soó from localities in N. Essex, W. Suffolk, Cambridge, and Huntingdon (1).

Parasitic on the roots of woody and herbaceous woodland plants. Observations have shown that the flowers are visited chiefly by Humble Bees. Failing insect pollination, movements of the stamens ensure fertilisation.

M. arvense L. Sp. Pl. (1753), 605. Icones "English Botany," t. 53.

An erect, showy, pubescent annual, about 40 cm. high, with terminal compact inflorescences invested with carmine-purple bracts. Stem with reflexed hairs, *c.* 2·5 mm. in diam., 4-angled. Lower branches usually arrested, the upper branches erect or ascending, usually flowering, 1–3 pairs. Laminae shortly petioled, linear-lanceolate, obtuse, entire, slightly dentate, or acutely dentate-lobate at base, margins recurved, 44–55 mm. long; intercalary leaves 0–3 (or more) pairs, *c.* 70 mm. long. Inflorescence 3–6 cm. long, interrupted below; bracts linear-lanceolate, ovate, to ovate-lanceolate, the lower green, the succeeding bracts green and purple, the upper carmine-purple, all with 4–6 pairs of linear-subulate basal lobes. Flowers shortly pedicelled, calyx-tube 6–7 mm. long, teeth as long as tube, linear-subulate from deltoid bases. Corolla 20–24 mm. long, tube curved below and contracted, carmine-purple, throat bright yellow, upper lip carmine, lower lip yellow and purple, mouth closed. Capsule compressed, broadly ellipsoidal, 10 × 6 mm., dehiscence ventral, seeds ellipsoidal, 6·5 × 2 mm., brown, becoming black. Flowering in July and August.

M. arvense is represented in Britain by two varieties. Subsp. *pseudobarbatum* Ronn. recorded from the Isle of Wight (1), requires confirmation (2).

Var. *arvense* Beauv. ap. Schinz et Keller, Fl. d. Schw., 3 Aufl., ii (1914), 305. Syn.: *M. arvense* subsp. *arvense* Ronn. V N G Zürich, lv (1910), 310. *M. arvense* subsp. *eu-arvense* var. *genuinum* sub-var. *typicum* Beauv. Mon., 525. Stem internodes many, branches 2–4 pairs, erect or ascending, cauline leaves 4–7 (10) mm. wide; intercalary leaves 0–3 pairs, inflorescence commencing at nodes 9–12. The usual representative of the species in Britain.

Var. *Schinzii* comb. nov. Syn.: *M. Schinzii* Ronn. ap. Schinz et Keller, Fl. de la Suisse (1909), 520. *M. arvense* subsp. *Schinzii* Ronn. V N G Zürich, lv (1910), 310. *M. arvense* subsp. *eu-arvense* var. *genuinum* subvar. *Schinzii* Beauv. Mon., 525, 531. Stem internodes less numerous than in preceding variety, branches erect, 2–3 pairs, cauline leaves 10–17 mm. wide, fleshy; intercalary leaves 0–1 pair, inflorescence commencing at nodes 7–9. St. Lawrence, Isle of Wight, T. A. Hanbury (1862) and A. Loydell (1902), both in Herb. Druce Det. C. E. Britton. Recorded for Costessy, Norfolk, by G. C. Druce in Report B.E.C., 1917, 40, but confirmatory specimens are absent from the Druce Herbarium.

A rare colonist in several southern and eastern counties of England: Isle of Wight, N. Hants, W. Sussex, E. Kent, N. Essex, E. Norfolk, N. Lincs, Bedford, Oxon, and Bucks. Probably not now to be found in many formerly recorded localities.

Parasitic on the roots of cereal crops and on the roots of adjacent graminæ. Extra-floral nectaries are present as dark-coloured sunken glands on the lower surfaces of the bracts. The flowers are adapted for pollination by Humble Bees, and are also visited by Diptera, Hemiptera, Coleoptera, and Lepidoptera. In the absence of insect visitors self-pollination occurs. The seeds resemble small grains of wheat and may be milled with the latter. Bread made from flour into which the ground seeds of *M. arvense* enter exhibits when cut small violet-coloured specks on the surface (Alfred Hills, "Essex Review," 1931, 3). This colouring matter is derived from the presence of Rhinanthine in the seeds. The plant has received the name of "Poverty Weed" in the Isle of Wight, and is locally known in Essex as "Hogmeteg" (A. Hills, *l.c.*).

Elsewhere (3) a brief survey is given of the progress made towards a knowledge of the forms of *M. pratense* L. inhabiting Britain, leading from the *Melampyrum latifolium flore albo labio inferiore duabus maculis luteis* of pre-Linnean botanists to the array of forms recognised by Dr. G. Beauverd of Geneva in the herbarium of the late Dr. G. C. Druce, and made known by the last-named botanist (4). More recently, Beauverd (5) has reported on additional material with the result that the British list has been considerably augmented. That there is scope for further discoveries may be inferred from the extreme polymorphism displayed by *M. pratense* L., for within its limits Beauverd (6) described two subspecies, twenty-four varieties, twenty-seven subvarieties, and twenty-five formae. Many of these forms have a restricted distribution, being confined to certain areas, *e.g.* about one dozen are endemic in Britain. There may be a difference of opinion as to the value of the grade assigned to certain of the forms described by Beauverd. Thus Soó in his later-published monograph (7) referred the majority of Beauverd's varieties and subvarieties to thirteen subspecies, leaving unplaced a number of little-known varieties (or subspecies) exhibiting cross-affinities. A study of the synonyms quoted by Soó shows that the following eight subspecies, *vulgatum*, *oligocladum*, *angustifrons*, *typus*, *alpestre*, *paludosum*, *montanum*, and *hians*, are identical with forms recognised by Beauverd as natives of Britain. The conclusions reached by Soó appear sound, and I would add to the preceding list of subspecies *M. commutatum* Tausch, and three British forms unknown as inhabitants of the European mainland. These are *scotianum*, *meridionale*, and *ericetorum*.

Importance is attached to the colour of the corolla. In most forms the tube is whitish, white, or very pale yellow, with the helmet and lips of a deeper yellow. In full exposure to sunshine it may happen that forms with normally pale corollas will produce flowers with uniformly yellow corollas. Amongst British forms subsp.

scotianum is alone credited with the corolla tipped with purple, magenta, or deep crimson. It is open to question whether this character is constant, and it is certain that it is not restricted to the subspecies in question. The plant distinguished as subsp. *alpestre* var. *extensum* not only possesses similarly coloured flowers but may also bear pallid flowers. Then, again, plants from the Highlands referred on high authority to var. *paludosum* have been received with flowers brightly coloured as in *scotianum.* These plants of var. *paludosum* with brightly variegated flowers are reserved for later attention when it is hoped that additional material will be available for study. A secondary development of anthocyanin occurs in the flowers of the forms assigned by Beauverd to his subsp. *eu-pratense*, that is to say, that the entire corolla assumes a lighter or deeper purple tint. This is very conspicuous at times, and as it is not evident in herbarium specimens, a knowledge of its former presence assists at times in the discrimination of the subspecies. The forms included under subsp. *vulgatum* Beauverd are said to possess flowers that do not assume a purplish hue. In general this may be the case, but it may be stated that communities of subsp. *commutatum* and of var. *digitatum* have been seen in which pale purple-lilac flowers were conspicuous. Plants described by Beauverd as subsp. *eu-pratense* var. nov. *anglicum* (5), distinguished by flowers tinted pale lilac, are considered by the writer to belong to var. *lanceolatum* and to require no detailed description.

It is a matter of observation that *M. pratense* is often found in the vicinity of certain species such as *Calluna vulgaris*, *Vaccinium Myrtillus*, *Quercus sessiliflora*, etc., but little is known of any preferences shown by the British subspecies of *M. pratense.* Subsp. *meridionale* has not been seen hitherto away from the company of *Vaccinium Myrtillus* (to which its roots have been found attached); subspecies *scotianum* and *paludosum* prefer situations where Sphagnum abounds, and subsp. *commutatum* perhaps evinces a partiality for the society of *Fagus sylvatica.*

M. pratense L. Sp. Pl. (1753), 605. Icones "English Botany," t. 113.

A sub-glabrous or scabrid annual 8–60 cm. high, usually branched, branches often arrested. Leaves shortly petioled, rounded or cuneate at base, linear, linear-lanceolate, or lanceolate-ovate, acute; intercalary leaves, when present, usually broader than cauline leaves. Lower bracts entire or dentate, hastate-dentate; upper bracts rarely entire, usually pectinate or palmatifid. Flowers spreading or erect (12)–16–(22) mm. long, shortly pedicelled; calyx $\frac{1}{3}$–$\frac{1}{2}$ as long as corolla, calyx-tube green or purplish, teeth adpressed, linear-subulate or setaceous, unequal, upper pair of teeth falcate; corolla-tube usually paler than compressed, yellowish helmet, lips ± connivent or distant, sometimes flecked with purple; capsule compressed, ovate-acuminate, spreading or deflexed, dehiscing ventrally, seeds 3–4, 5 mm. long. Flowers May to October.

Woodlands, heaths, and moorlands throughout Britain ascending to 1000 metres. Apparently absent from a few districts. The roots of *M. pratense* are attached by means of haustoria to the roots of woody or herbaceous plants, or even to humus. Cross-pollination of the flowers is effected by long-tongued bees, in the absence of whose visits movements of the stamens and style bring about the deposition of the pollen upon the stigma. Extra-floral nectaries are present on the cotyledons, leaves, and bracts.

Subsp. *alpestre* (Brügger) Ronn. ap. V N G Zürich, lv (1910), 332. Syn.: *M. pratense* subsp. *eu-pratense* var. *alpestre* subvar. *eu-alpestre* Beauv. Mon., 487.

The typical form of this subspecies is not known to occur in Britain. A variation gathered on the Scottish mountains differs in the following characters: leaves hairy, inflorescence commencing at a lower node, elongated calyx-teeth, larger corolla, the latter not invariably tipped with crimson, but at times pale yellow or whitish. It is described as a new variety.

Var. *extensum* var. nov. Herba 15–20 cm. alt., internodium hypocotyleum elongatum (50) 100 (150) mm. lg., internodia sequentia reducta, 20–40 mm. lg. Caulis simplex vel basi breviter ramosus, ramis par unum sterilibus vel parum florigeris, arcuato-erectis. Cotyledones (superf. 30 × 7 mm.) subanthesi adsunt. Folia caulina lineari-lanceolata (superf. 40 × 2 mm.) folia intercalaria nulla. Bracteae lineari-lanceolatae 40 × 4–5 mm. integrae. Inflorescentiae initium in secundo (rarius tertio) nodo situm. Calyx tubo 2 mm. lg., dentibus 6–7 mm. lg., corolla 14–16 mm. lg. albida, luteola vel purpureo-variegata.

Type in Herb. C. E. Britton, collected by Messrs. Mackechnie and Wallace at Craig Laoghain, Meall Gheardie, Mid Perth, v.c. 88, 12th July 1938. Other localities are: Lochnagar, S. Aberdeen, v.c. 92, collected by J. E. Lousley at 2500 feet alt. on 24th July 1938 ("corolla with pure white tube, collar deep red—palate yellow"). Ben Lui, Argyll, v.c. 98, collected by J. E. Lousley at 2500 feet alt. on 17th July 1938 ("red corolla"). I have seen this variety from other stations.

Plant 13–20 cm. high, lax, foliar organs distant. Hypocotyl (50) 100 (150) mm. long; stem internodes 20–40 mm. long. Stem simple or branched, branches arising from axils of cotyledons, sterile, or occasionally bearing a few flowers, and arcuate-erect. Cotyledons oblong-spathulate, 30 × 7 mm. Cauline leaves linear-lanceolate, about 40 × 2 mm.; intercalary leaves absent. Bracts entire, linear-lanceolate, 40 × 4–5 mm. Inflorescence commencing at node 2 (rarely at node 3). Calyx-tube 2 mm. lg., teeth 6–7 mm. long. Corolla 14–16 mm. lg., whitish or pale yellow, variegated with crimson or not.

Subsp. *scotianum* (Beauv.) comb. nov. Syn.: *M. pratense* subsp. *eu-pratense* var. *alpestre* subvar. *scotianum* Beauv. Mon., 486; *M. pratense* subsp. *montanum* var. *scotianum* Soó, Mon., 186.

Scabrous in all parts; about 10 cm. in height, often contracted and foliar organs contiguous, stem internodes 4–5 mm. lg., branches usually short and sterile. Cotyledons persistent or deciduous, 15–20 × 3–5 mm. Cauline leaves lanceolate-linear, thick, 25–40 × 2–3 mm., intercalary leaves usually absent. Inflorescence commencing at nodes 3–4 (rarely at node 2); lower bracts lanceolate-linear, entire; upper bracts entire or with a few distant teeth at base. Calyx-tube 2 mm. lg., teeth 5 mm. lg. Corolla 12 mm. lg., usually tipped with crimson.

Recorded from many Scottish localities, from the North of England, and from Ireland.

Subsp. *meridionale* nom. nov. Syn.: *M. pratense* subsp. *eu-pratense* var. *alpestre* sub-var. *elongatum* (8) Beauv. ap. C. E. Britton in Journ. Bot., 1939, 83; non *M. pratense* subsp. *eu-pratense* var. *elongatum* Beauv. Mon., 491.

Lax plants 20–30 cm. high; internodes of stem 30–45 mm. lg.; branches 1–2 pairs, 15–20 cm. lg., spreading or ascending, internodes 45–100 mm. lg. Cotyledons oval-spathulate, 20–35 × 5–6 mm., present or absent at flowering-time. Cauline leaves linear, 30–60 × 2–3 mm., usually one pair; intercalary leaves 0 or 1 pair, broadly linear. Inflorescence commencing at nodes 3 or 4. Lower bracts linear-lanceolate, entire, 40 × 5 mm., apical bracts entire or incised-dentate at base. Calyx-tube 2 mm. lg., teeth 3 mm. lg. Corolla 15 mm. lg., tube yellowish, bosses of lower lip orange.

At present only known from the Hythe beds of the Lower Greensand of Surrey and W. Kent, where *Vaccinium Myrtillus* L. is found. Suggested by Beauverd to be a luxuriant southern homologue of the northern *M. pratense* subvar. *scotianum* hence the subspecific epithet chosen.

Subsp. *typicum* (Beck) Ove Dahl ap. Blytt, Haandb. Norg. Fl. (1906), 641. Syn. *M. pratense* subsp. *eu-pratense* var. *typicum* subvar. *foliatum* Beauv. Mon., 488. *M. pratense typus* Soó, Mon., 183.

Plants 12–30 cm. high. Stem stout or slender, branches 1–2 (3) pairs spreading or ascending, leafy at apex, usually sterile. Cotyledons 25 × 6 mm. present or absent at flowering-time. Cauline leaves 1–3 pairs, linear-lanceolate, intercalary leaves 0 or 1 pair. Inflorescence commencing at nodes 3 or 4 (rarely 5). Lower bracts entire, linear-lanceolate, apical bracts hastate at base. Flowers about 15 mm. lg., calyx-tube 2 mm. lg., teeth about 2 mm. lg.

f. *foliatum* Neum. Sveriges Fl. (1901), 150. Stem internodes about 40 mm. lg., branches about 8 cm. lg., obliquely erect; cauline leaves about 50 × 5 mm., intercalary leaves 0, inflorescence commencing at nodes (2) 3 (4), bracts about 40 × 7 mm.

f. *laxum* Beauv. Mon., 488. Stem internodes 40–100 mm. lg., branches spreading, cauline leaves about 40 × 4 mm. lg., intercalary leaves often present, inflorescence commencing at nodes 3 or 4 (5), bracts about 50 × 9 mm.

Few records from the south, perhaps more frequent in the north. Surrey, Sussex, Swindale Beck and Great Rundle Tarn, Westmorland, v.c. 69; Black Wood of Rannoch and Allt nain Coire, Pleiginn Keltney Burn, Mid Perth, v.c. 88; Glen Ey, S. Aberdeen, v.c. 92; pine woods, Grantown-on-Spey, Elgin, v.c. 95; woods by Loch Leuchard, Ross-shire. Usually occurrs as f. *laxum* Beauv.

Subsp. *paludosum* (Gaud.) Soó, Mon., 185. Syn.: *M. pratense* var. *paludosum* Gaudin, Fl. Helv., iv (1829), 122. *M. pratense* subsp. *eu-pratense* var. *paludosum* subvar. *eu-paludosum* Beauv. Mon., 490. *M. montanum* Johnston, Fl. Berwick-on-Tweed, i (1829), 136.

Slender or very slender plants 12–25 cm. high, hispidulous. Stem erect, internodes 12–30 mm. lg., branches erect or ascending, rarely spreading, 1–2, seldom 3 pairs, lowest pair or pairs occasionally arrested. Cotyledons persistent or deciduous. Cauline leaves, intercalary leaves, and bracts narrowly linear, elongated bracts entire. Inflorescence commencing at nodes 3–7. Flowers 12–16 mm. lg.

Var. *paludosum* Gaud., *l.c.* Cauline leaves 2–3 pairs, branches 1–3 pairs, typically erect, the uppermost pair alone reaching full development at times. Intercalary leaves 1–3 pairs. Inflorescence commencing at nodes 6–7. Calyx-tube 2 mm. lg., teeth 2·5 mm. lg., corolla 13–16 mm. lg.

Var. *montanum* (Johnst.) Bab. Man. Br. Bot., 1843, 220. Syn.: *M. montanum* Johnston, Fl. Berwick-on-Tweed, i (1829), 136. *M. pratense* var. *montanum* Bab., *l.c.*, non *M. pratense* subsp. *eu-pratense* var. *montanum* Beauv., Mon., 493, nec *M. pratense* subsp. *montanum* Soó, Mon., 185. Cauline leaves 1–2 pairs, branches 1–2 pairs, ascending, the lowest pairs (from axils of cotyledons) usually arrested. Intercalary leaves 1 pair, rarely 0 or 2 pairs. Inflorescence commencing at nodes (3) 4–5 (6). Calyx-tube 2–3 mm. lg., teeth 3–4 mm. lg., corolla pallid, 12 mm. lg.

Records for var. *paludosum* are scanty. The most satisfactory examples seen hitherto are from Gower, Glamorgan, v.c. 41, and from Wybunbury Moss, Cheshire, v.c. 58. Plants with red-tipped flowers, apparently constituting a form of var. *paludosum*, occur in the Scottish Highlands and require further attention. Fresh material would be appreciated.

Var. *montanum* is not sufficiently known for the census number of 20 given in Druce's "British Plant List," ed. 2 (1928), to be accepted. Recent records are from Cheviot (Revd. J. E. Hull) and from Tyndrum, Mid Perth, v.c. 88 (E. C. Wallace). The description of var. *montanum* given in this paper is based upon specimens from the Cheviots collected and named by Johnston and now in the herbarium of the Royal Botanic Garden, Edinburgh, and in Herb. Brit. Mus. (2). There is considerable misunderstanding of this variety. Beauverd states that the form named by him as *scotianum* has been accepted by British botanists as Johnston's plant. I would add also that forms of subsp. *ericetorum* have been mis-identified and similarly named.

Subsp. *ericetorum* (D. Oliver) comb. nov. Syn.: *M. pratense* var. *ericetorum* D. Oliver in "Phytologist," 1852, 678. *M. pratense* subsp. *eu-pratense* var. *ericetorum* Beauv., Mon., 493. *M. pratense* subsp. *montanum* var. *ericetorum* Soó, Mon., 186.

Plants 10–30 cm. high, hispidulous or subglabrous. Stem erect or inclined, branched from the base, branches 2–3 pairs, ascending or sub-erect, equalling or falling short of stem, all flowering or the lower branches, rarely all, arrested. Cotyledons deciduous or persistent, 11–16 × 4–6 mm. Cauline leaves spreading or declining, 25–60 × 2·5–6 mm., linear or lanceolate, intercalary leaves 0 or 1–2 pairs. Inflorescence commencing at nodes 4–7, lower bracts linear or linear-lanceolate, entire, upper bracts with 2–3 pairs of linear or subulate teeth, rarely hastate-dentate or entire. Flowers 12 mm. or more lg., calyx-tube 2–3 mm. lg., teeth 3–4 mm. lg.

Var. *ericetorum* D. Oliver *l.c.* C. E. Britton in Report B.E.C., 1938, 99. Intercalary leaves 1–2 pairs, inflorescence commencing at nodes 6–7.

Var. *decipiens* (Beauv.) comb. nov. Syn.: *M. pratense* subsp. *eu-pratense* var. *ericetorum* subvar. *decipiens* Beauv. ap. C. E. Britton, Journ. Botany, 1939, 84. Intercalary leaves 0–1 pair, inflorescence commencing at node 4 (5). More frequent than var. *ericetorum* D. Oliver: W. Kent, Surrey, Hants, Wilts, Cardigan, Mid Perth, Westerness.

f. *confine* forma nov. Herba gracilis ± 12–16 cm. alt., caulis tenuis ± ·5 mm. diam. Folia et bracteae linearia vel lanceolata-linearia, acuminatae, elongatae, bracteae integrae, interdum dentatae vel pectinatae. Flores interdum aurea.

General characters of var. *decipiens*, 12–16 cm. high, stem slender, ·5 mm. diam., leaves and bracts narrow, elongated, acuminate; bracts entire or apical toothed or pectinate. Flowers pale (or golden in specimens from Achill Island, W. Mayo).

Type in Herb. C. E. Britton (No. 4459), collected by Miss E. S. Todd at Glen Roy, v.c. 97, 17th July 1939. Also grows at Leith Hill, Surrey, v.c. 17.

Var. *propinquum* var. nov. Herba nana 10–15 cm. alt. subsimplex vel ramosus, ramis brevibus sterilibus vel arcuato-erectis. Folia caulina linearia *c.* 25 × 3 mm. folia intercalaria linearia unum par. Inflorescentiae initium ad 4–5 node situm, bracteae lanceolatae integrae vel apicales basi hastato-dentatae.

Dwarf plants 10–15 cm. high, branched, stem-internodes 6–15 mm. lg., branches 1–2 pairs, floriferous 6–9 cm. lg., arcuate-erect, equalling or exceeding stem, or stems sub-simple, internodes 25–30 mm. lg., branches weak, arrested, and sterile. Cauline leaves linear obtuse, about 25 × 3 mm., intercalary leaves one pair. Inflorescence commencing at nodes 4 or 5, lower bracts obtuse, 25–40 × 3–6 mm., lanceolate, entire, apical bracts entire or hastate-dentate at base.

Type in Herb. C. E. Britton, collected by P. M. Hall and E. C. Wallace (No. 3499) at Ard Skinid, west of Tongue Bay, v.c. 108, 4th July 1939. Similar plants were collected by Dr. T. Stephenson at Pont Erwyd, Cardigan, v.c. 46, in July 1941.

Var. *proximum* var. nov. Herba subvalida ± 30 cm. alt., caulis 2 mm. diam., internodiis 40–50 mm. lg., ramosus, ramis oblique-erectis plerumque sterilibus, tria paria. Folia caulina duo paria anguste lanceolata (superf. 50–60 × 5–6 mm.), patula remota, folia intercalaria unum par (rarius nulla). Inflorescentiae initium ad 5 (6) nodo situm. Bracteae inferiores lanceolatae (superf.

50 × 7 mm.) integrae, apicales basi dentatae. Flores 15 mm. lg., calyx-tubo 2 mm. lg., dentibus 3 mm. lg.

Robust, stem about 30 cm. high, 2 mm. diam., internodes 40–50 mm. lg., branches ascending or erect, usually arrested and sterile, seldom exceeding or twice as long as internodes. Leaves remote, elongated (50–60 mm. lg.), intercalary leaves one pair, seldom none. Inflorescence commencing at nodes 5 (or 6). Flowers 15 mm. lg., calyx-tube 2 mm. lg., teeth 3 mm. long.

Type in Herb. C. E. Britton (No. 4385), collected by Dr. T. Stephenson at Chudleigh Knighton, S. Devon, v.c. 3, 12th June 1939.

Subsp. *oligocladum* (Beauv.) Soó, Mon., 180.

Plants 18–30 cm. high, stems robust, branched, branches arcuate-erect or ascending, 1–2 pairs, originating in axils of cotyledons and succeeding pair of leaves. Cauline leaves linear-lanceolate, one pair, intercalary leaves none (rarely one pair). Inflorescence commencing at node 3, rarely at node 4.

Var. *oligocladum* Beauv. Syn.: *M. pratense* subsp. *vulgatum* var. *oligocladum* Beauv. Mon., 493. Cotyledons and leaves usually present at flowering-time; branches erect-ascending; lower bracts ovate-lanceolate, entire; apical bracts pectinate-dentate.

Var. *britannicum* Beauv. Syn.: *M. pratense* subsp. *vulgatum* var. *britannicum* Beauv. Mon., 497. Cotyledons and leaves usually absent at flowering-time; branches elongated, leafy in upper part only, arcuate-erect; lower bracts linear-lanceolate, entire; apical bracts sub-hastate-dentate at base.

Subsp. *oligocladum* (Beauv.) Soó appears to be of rare occurrence and the recorded localities are few in number and mostly in the south. There is a record of var. *britannicum* from Skye.

Subsp. *commutatum* (Tausch) comb. nov. Syn.: *M. commutatum* Tausch, Pl. select No. 1201, ap. Koch, Synopsis Fl. Germ., ed. 2 (1843), 621. *M. pratense* var. *commutatum* G. Beck, Fl. N.Ö., ii, 2 (1893), 1070. *M. pratense* subsp. *vulgatum* var. *commutatum* Beauv. Mon., 500–2.

Stem robust, 40–50 cm. high, 2–3 mm. in diam., glabrous, nodes distant, internodes 40–60–120 mm. lg. Cauline leaves 4–5 pairs, all with branches from axils, lowest branches ± arrested, branches from middle of stem erect or ascending, floriferous, usually again branched. Cauline leaves lanceolate to ovate-lanceolate, acuminate, intercalary leaves oval-lanceolate. Inflorescence commencing at nodes 5 to 12; lower bracts resembling intercalary leaves but with short teeth at base; intermediate bracts lanceolate, hastate-dentate at base; apical bracts palmatifid. Calyx-tube 2 mm. lg., teeth 3 mm. lg., corolla 13 mm. lg., tube whitish, helmet and lips pale yellow. In full exposure, corollas become uniformly pale yellow.

f. *concolor* comb. nov. Syn.: *M. pratense* var. *concolor* Schönheit in Sched., Fl. Bavarica, No. 202 (1899). *M. pratense* subsp. *vulgatum* var. *commutatum* subvar. *concolor* Beauv. Mon., 500. Lower leaves usually fallen at flowering-time, upper cauline leaves lanceolate 40–60 × 8–12 mm., intercalary leaves many (4–5 pairs), broadly lanceolate, 40–50 × 10–13 mm.; inflorescence commencing at nodes 8–12.

f. *pseudo-nemorosum* (Beauv.) Soó, Mon., 178. Syn.: *M. pratense* subsp. *vulgatum* var. *commutatum* subvar. *pseudo-nemorosum* Beauv. Mon., 500. Upper cauline leaves broadly lanceolate to ovate-lanceolate, 45–65 × 10–20 mm.; intercalary leaves several (2–4 pairs), broadly lanceolate, ovate-lanceolate to ovate, 50–65 × 15–20 mm.; inflorescence commencing at nodes 6–8.

f. *ovatum* (Spenn.) Beck. Syn.: *M. pratense* var. *ovatum* Spenner, Fl. Frib., ii (1826), 367. *M. pratense* subsp. *vulgatum* var. *vulgatum* subvar. *digitatum* f. *ovatum* Beauv. Mon., 508. *M. pratense* var. *commutatum* f. *ovatum* G. Beck, Fl. N.Ö., ii, 2 (1893), 1070. Upper cauline leaves ovate-lanceolate or oval-ovate, 50 × 15 mm.; intercalary leaves 0 or 1 (2) pairs, oval-ovate, 50–55 × 18–20 mm.; inflorescence commencing at nodes 5–6.

In any of its forms, subspecies *commutatum* is usually easy to recognise. As the width of the intercalary leaves and bracts increase, the number of these organs become less. A community may consist of one form only, or two, or even all three forms grow intermixed. The subspecies probably has a wide distribution, although so far no examples from Scotland have come under notice. There are many stations for it in Kent, where it favours banks, hedgerows, and edges of woods on chalk soil. Plants to be referred to this have been gathered in the vicinity of the River Wye in the west of England; other localities are in Warwickshire and Lancashire. In Ireland it is known for Killarney.

Subsp. *vulgatum* (Pers.) Ronn. ap. V N G Zürich, lv (1910), 321 (excluding var. *commutatum* (Tausch) Beauv.). Syn.: *M. vulgatum* Pers. Syn., ii (1807), 151, s.s., *M. pratense* subsp. *vulgatum* var. *vulgatum* Beauv. Mon., 502–3.

Stems 10–50 cm. high, branches originating from the axils of most leaves; lowest branches often arrested and sterile; upper elongated, spreading, and flowering. Cauline leaves linear; intercalary leaves and bracts linear-lanceolate (rarely elliptical-lanceolate). Inflorescence commencing at nodes 4–7; lower bracts entire or sub-dentate at base, upper and apical bracts usually more incised than in subsp. *commutatum*. Calyx 4–8 mm. lg., corolla-tube whitish, helmet and lips pale yellow: corolla uniformly pale yellow when plants grow in full exposure to light.

Var. *lanceolatum* Spenner, Fl. Frib., ii (1826), 367. Syn.: *M. pratense* var. *lanceolatum* Spenn., *l.c.* *M. pratense* subsp. *vulgatum* var. *vulgatum* subvar. *digitatum* f. *lanceolatum* Beauv. Mon., 507. Stems 25–35 cm. high, often secund at apex, branches ascending. Cotyledons present at commencement of flowering period. Cauline leaves linear-lanceolate acuminate, 25–80 × 4–10 mm.; intercalary leaves similar to upper cauline leaves, 1–2 pairs, rarely none. Inflorescence commencing at nodes 4–6; lower bracts similar to cauline leaves, entire; succeeding bracts smaller, pectinate at base; apical bracts palmatifid. Flowers 14–15 mm. lg., calyx-tube 2 mm. lg., teeth 3 mm. lg.

f. *expansum* forma nov. A var. lanceolato typico differt: ramis horizontaliter patentibus vel procumbentibus elongatis (15–25 cm. lg.), internodiis 50–80 mm. lg.

A form of var. *lanceolatum* with widely spreading procumbent branches and elongated internodes.

Var. *lanceolatum* is one of the most widely spread forms of *M. pratense* L. A lusus with many intercalary leaves has been found in Essex. To f. *expansum* belong plants from Epping Forest, Essex, distributed through the Botanical Exchange Club in 1935 under the numbers 4212 and 4213. These plants were subsequently referred to *M. pratense* subsp. *vulgatum* f. *divaricatum* Ove Dahl (Report B.E.C., 1935, 101), a plant of Norway, Sweden, and Lapland. Beauverd, who later saw examples, referred them to f. *lanceolatum* with the comment "ad f. *divaricatum* area Scandinavica ± vergens." Similar plants have been seen in W. Kent, v.c. 16, and in Surrey, v.c. 17.

Var. *laurifolium* comb. nov. Syn.: *M. pratense* subsp. *vulgatum* var. *vulgatum* subvar. *laurifolium* Beauv. Mon., 507. Lax plants 20–40 cm. high, with elongated internodes 20–40 mm. lg., branches ascending or divergent, flowering. Cotyledons oblong-oblanceolate, 20 × 5 mm., present when first flowers expand. Cauline leaves oblong-lanceolate or elliptical-lanceolate, base rounded, acuminate, 50–70 × 12–20 mm., intercalary leaves (usually one pair) and lower bracts long and broad, 70–100 × 18–23 mm., succeeding bracts decreasing in size, with 1–2 pairs of basal teeth, upper bracts palmatifid. Inflorescence commencing at nodes 4 or 5. Flowers 13–15 mm. lg., calyx-tube 2 mm. lg., teeth 4 mm. lg.

Recorded from a few localities in the south of England.

Var. *digitatum* Schur, En. Pl. Transs. (1866), 506.

Stems about 40 cm. high, erect or flexuose, branches from axils of all cauline leaves, spreading or ascending, the upper branches equalling or exceeding main stem. Cotyledons not present at flowering-time. Cauline leaves oval-lanceolate, spreading, 75–85 × 15–20 mm., intercalary leaves 0–2 pairs oval-lanceolate, 65 × 15 mm. Inflorescence commencing at node 7, lower bracts oval-lanceolate entire, succeeding bracts hastate at base, upper bracts deltoid, palmatifid, very numerous. Calyx-tube 2 mm. lg., teeth 3·5 mm. lg. Distinguished by the elongated broad leaves and very numerous deeply cut bracts terminating the stem and branches. Uncommon.

Var. *devonianum* comb. nov. Syn.: *M. pratense* subsp. *vulgatum* var. *vulgatum* subvar. *devonianum* Beauv. ap. C. E. Britton in Journ. Bot., 1939, 85.

Stems 25–28 cm. high. Cotyledons and lower or all cauline leaves already fallen at flowering-time. Lower 2–3 pairs of branches slender and sterile, upper pair of branches spreading-ascending floriferous, intercalary leaves one pair, lanceolate, 50–55 × 5–9 mm. Inflorescence commencing at node 6; lower bracts lanceolate, 50–70 × 6–13 mm., entire; apical bracts palmatifid. Calyx-tube 2 mm., teeth 3 mm., corolla 15 mm. lg.

Woodbury, S. Devon, v.c. 3.

Subsp. *angustifrons* (Borbás) Soó, Mon., 181. Syn.: *M. pratense* var. *angustifrons* Borbás, Vasm. Fl. (1888), 230, sec Soó. *M. pratense* subsp. *vulgatum* var. *integerrimum* f. *vogesiacum* Beauv. Mon., 516.

Stems 15–25 cm. high, branched, lower branches usually arrested and sterile, succeeding 1–2 pairs well-developed, arcuate, branched, and flowering. Cauline leaves linear-lanceolate, 35–60 × 2–6 mm.; intercalary leaves (1)–2–3–(4) pairs resembling cauline leaves. Inflorescence commencing at nodes 6–8; lower bracts entire, upper bracts entire or dentate or pectinate-dentate.

Var. *vogesiacum* Beauv. in Schinz et Keller, Fl. d. Schw., ed. 3 (1914), 306, as var. of subsp. *hians* (Druce) Beauv. Cauline leaves 50 × 5 mm., intercalary leaves resembling cauline leaves, lower bracts 55–70 × 7 mm. entire, apical bracts smaller, with 1–2, rarely 3, pairs of distant spreading or ascending linear lobes at base.

Felbridge, Surrey, v.c. 17 (A. Beadell), Journ. Bot., 1939, 86; Copthorne, Sussex, v.c. 14 (A. Beadell).

Var. *pseudo-silvaticum* Schur, En. Pl. Transs. (1866), 506. Syn.:

M. pratense subsp. *vulgatum* var. *integerrimum* f. *pseudo-silvaticum* Beauv. Mon., 516. Cauline leaves narrowly linear-lanceolate, 45–55 × 4–6 mm., intercalary leaves linear-lanceolate, 35–55 × 4–9 mm., lower bracts similar, entire; upper bracts smaller, entire, or slightly dentate-hastate at base.

Uncommon, south of England, Northumberland, Aberdeen.

Subsp. *hians* (Druce) Beauv. ap. Schinz et Keller, Fl. d. Schw., Aufl. 3 (1914), 30. Syn.: *M. pratense* var. *hians* Druce in "Naturalist" (1884), 35. *M. vulgatum* var. *hians* Druce in "New Phytologist" (1912), 361. *M. pratense* subsp. *vulgatum* var. *hians* Beauv. Mon., 514.

Stems 20–30 cm. high, internodes elongated, branches originating at lower nodes usually arrested, upper branches erect or erect-ascending, equalling stem, floriferous, secondary branches usually flowerless. Cotyledons, 20 × 4 mm., deciduous or sub-persistent. Leaves and bracts narrow or broad, intercalary leaves present or absent. Flowers often erect; calyx-tube 2·5 mm. lg., teeth 5 mm. lg., corolla 15 mm. or more in length, normally golden-yellow or verging on to orange.

Var. *hians* Druce, *l.c.* Syn.: f. *stenophyllum* Beauv. Mon., 514. Cauline leaves linear-lanceolate, 40 × 5 mm., usually cuneate at base, intercalary leaves 0–1–2 pairs. Inflorescence commencing at nodes 4–5–(6), lower bracts lanceolate entire, upper bracts hastate or pectinate at base (occasionally entire). The normal form. f. *pallescens* Beauverd ap. C. E. Britton in Journ. Botany, 1939, 85. Habit of typical plant, flowers pale yellow or whitish.

f. *minus* forma nov. Caulis humilis, *c.* 13 cm. alt., ramosus, ramis debilibus sterilibus (rarius florigeris). Cotyledons (superf. 15 × 4 mm.) sub anthesi adsunt. Folia caulina anguste linearia ± 45 × 2–3 mm. unum par, folia intercalaria linearia 25–35 × 3 mm. unum par. Inflorescentiae initium in quarto (rarius quinto) nodo situm; bracteae lanceolatae integrae erectae. Flores fasciculati, pauci (3–4), corolla 20 mm. lg., aureo-lutea.

Type in Herb. C. E. Britton (No. 4461), collected by Dr. T. Stephenson near Dunkery Beacon (at an altitude of 1500 feet), Somerset, v.c. 5.

Distinguished by small size, slender habit, branches from cotyledonary node and second node usually weak and sterile (seldom flowering). Inflorescence commencing at node 4; bracts entire, erect; intercalary leaves one pair; flowers few, clustered, larger than usual.

Var. *amplifolium* nom. nov. Syn.: *M. pratense* subsp. *vulgatum* var. *hians* f. *platyphyllum* (8) Beauv. Mon., 514. Non *M. pratense* var. *platyphyllum* Hayek ap. Hegi, Fl. M.E., vi (1916), 80. Plants robust, leaves oblong-lanceolate or ovate-lanceolate, bracts broadly lanceolate or ovate-lanceolate, upper bracts with linear spreading teeth at base; inflorescence often commencing at node 3; flowers golden.

f. *pallidiflorum* forma nov. Corolla albida vel pallide lutea. Characters of var. *amplifolium*, but with whitish or pale yellow flowers.

Var. *hibernicum* Druce in Report B.E.C., iv, part 3 (1915), 205. Leaves and bracts as in var. *amplifolium* but less elongated, the bracts acute not acuminate, intermediate bracts with four distant awl-shaped teeth at base; flowers golden-yellow.

The plants included under subsp. *hians* appear to favour the western and northern districts of Britain. As the characteristic feature of the subspecies is the rich yellow colour of the corolla, so at times the name *hians* has been applied to dissimilar forms with uniformly yellow corollas. Plants recorded as var. *hians* from localities outside the distribution area require careful scrutiny, particularly those from the south and south-east of England. The formae *pallescens* and *pallidiflorum* may be met with as solitary plants amongst normal-flowered individuals, and also occur in communities from which the golden-flowered plants are absent. Forma *minus* was reported by the finder as growing amongst short heather (*Calluna*) and believed to be plentiful all over Exmoor. Var. *hibernicum* is known in Britain at localities in Cornwall and has also been recorded from several localities in Ireland.

The variations of *M. silvaticum* L. have received little attention hitherto from native botanists. An interesting form with pale flowers was found many years ago by Buchanan White growing with the common form in Blairathole Woods, East Perth, and described under the name of var. *pallidiflorum*. The same or a similar form was later found by G. C. Druce in Glen Tilt, East Perth, "growing in great masses." There are several forms of *M. silvaticum* L. with pale flowers recognised by continental botanists, and it would be of interest to learn whether the Perthshire plant is identical with any of these. Fresh examples would be welcome. Very many varieties and forms of lesser grade have been distinguished within the limits of *M. silvaticum*, but so far only two of these have been recorded from the British Isles. Schinz and Keller, Ronniger, and Soó have recognised that the Linnean

M. silvaticum covers a number of species or subspecies. The last-named botanist distinguished seven subspecies, four of which occur in Switzerland. These are *silvaticum* (L.) Ronn., *subsilvaticum* (Sch. and Ronn.) Soó, *aestivale* Ronn., and *laricetorum* Ronn. The first of these subspecies is not unlikely to occur in Britain, the second has been identified by Soó (1), and I refer plants from Teesdale and from Ireland to subspecies *aestivale* Ronn. It is doubtful whether subsp. *laricetorum* is likely to occur.

M. silvaticum L. Sp. Pl. (1753), 605. Icones "English Botany," t. 804.

A slender or robust pubescent or subglabrous annual 15–35 cm. high, with erect widely gaping flowers. Stem branched, rarely simple. Leaves shortly petioled, intercalary leaves 0 or 1–2 pairs. Inflorescence commencing at nodes 3–5. Bracts resembling cauline leaves, but broader, entire (=var. *edentatum* Schur, En. Pl. Transs. (1866), 506) or with 1–2 pairs of teeth above cuneate base (=var. *dentatum* Schur, *l.c.*). Flowers 8–10 mm. long, shortly pedicelled, calyx-tube glabrous, blotched with purple, shorter than erect-spreading linear-lanceolate, ultimately often oblong-lanceolate, equal teeth. Corolla deep yellow, tube curved, lower lip deflexed, often marked with purple, distant from upper lip; rarely whitish or pale yellow (=var. *pallidiflorum* Buch.-White in "Scottish Naturalist" (1875), 20). Capsule ovate-compressed, spreading or reflexed, dehiscing dorsi-ventrally, seeds 5 × 2 mm. Flowering June to August.

Subsp. *subsilvaticum* (Schinz et Ronn.) Soó, Mon., 168. Syn.: *M. intermedium* Ronn. et Schinz ap. Schinz et Keller, Fl. de la Suisse (1909), 521, non *M. intermedium* Perr. et Song. ap. Bull. Herb. Boiss. (1894), 426-7. *M. silvaticum* subsp. *intermedium* Ronn. V N G Zürich, lv (1910), 326. *M. subsilvaticum* Schinz et Ronn. ap. Fl. d. Schw., ii, 3 Aufl. (1914), 303. Var. *dentatum* f. *obscurum*. Var. *edentatum* subvar. *nephelobium*. Subvar. *dubium* Beauv. Mon.

Stem 15–30 cm. high, internodes elongated, 25–30 mm. long; branches 1–3 pairs strict or ascending, frequently all arrested and sterile. Cotyledons not present at flowering-time. Cauline leaves thin, 2–10 mm. wide, intercalary leaves 0. Inflorescence commencing at nodes 4–5. Bracts usually entire. f. *stenophyllum* (Beauv. Mon., 598) Soó, Mon., 169. Leaves 2–3 mm. wide. f. *platyphyllum* (Beauv. Mon., 599) Soó, Mon., 169. Leaves 8–10 mm. wide. f. *dentatum* (Schur) Soó, Mon., 169. Bracts furnished at the base with 1–2 pairs of small teeth.

Var. *Toddae*, var. nov. Caules 22–30 cm. alta, nodia tria inferiores longe ramosi, ramis arcuato-patentibus ± subramificatis florigerisque 15–20 cm. lg. Folia caulina lanceolata-linearia (superf. 50–60 × 3–4 mm.) sub anthesi desunt, folia intercalaria nulla vel paria dua, caulinis similia vel breviora. Inflorescentiae initium in quarto quintove (rarius sexto) nodo situm. Bracteae linearia-lanceolata (superf. 50–60 × 4–6 mm.) entire. Flores 8 mm. lg., calyx tubo purpureo-maculato, dentibus lineari-lanceolatis, corollae tubo subaequalibus. Corolla aurea-lutea, labio inferiore post anthesin rosea.

Stems 22–30 cm. high, branched from the base, branches spreading-ascending or arcuate-erect, 15–20 cm. long, usually three pairs, arising from the three lowest nodes. Cauline leaves (when seen) lanceolate-linear, acuminate, 50–60 × 3–4 mm. Intercalary leaves 0 or 1–2 pairs. Inflorescence commencing at nodes 4–5 (rarely 6). Bracts linear-lanceolate acuminate entire, 50–60 × 4–6 mm. Flowers 8 mm. long, calyx-tube blotched with purple, teeth equalling corolla tube, corolla golden-yellow, lower lip finally becoming pale red.

Type (No. 4383) in Herb. C. E. Britton, collected by Miss E. S. Todd at Aberfeldy, Mid Perth, v.c. 88. Plants of similar habit have been collected at Glen Roy.

Subsp. *aestivale* Ronn. V N G Zürich, lv (1910), 328. Syn.: *M. aestivale* Ronn. et Schinz ap. Schinz et Keller, Fl. de la Suisse (1909), 521. *M. silvaticum* subsp. *eu-silvaticum* var. *edentatum* subvar. *latifolium* (Hartman) Beauv. Mon., 592, p.p.

Stem 15–35 cm. high, internodes 35–50 mm. long; simple or with 1–2 pairs of erect, rigid sterile branches. Cotyledons present or absent at flowering-time. Foliage thick and fleshy. Cauline leaves 40–60 × 9–10 mm., intercalary leaves 0. Inflorescence commencing at nodes 3–4. Bracts ovate-lanceolate, 50–60 × 12–20 mm., entire, or upper bracts bidentate at base.

England: Teesdale, Co. Durham, v.c. 66. Specimens in Herb. Mus. Brit. and in Herb. Druce. Ireland: Co. Down, v.c. 38; Co. Antrim, v.c. 39. Specimens in Herb. Mus. Brit.

I am indebted to my friend Mr. Walter Johnson for useful suggestions and am under obligations to the staffs of the British Museum (Nat. History) and South London Botanical Institute for facilities to consult the herbaria and libraries.

REFERENCES.

(1) SALMON, C. E.: "Notes on Melampyrum." Journ. Botany, 1929, 105.
(2) BRITTON, C. E.: "Notes on Melampyrum." Report B.E.C., 1938, 97.

(3) Britton, C. E.: "*Melampyrum pratense* in the Druce Herbarium." Report B.E.C., 1934, 909–18.
(4) Druce, G. C.: "Melampyrum." Report B.E.C., 1917, 40–48.
(5) Britton, C. E.: "*Melampyrum pratense*: recent determinations and views of Dr. G. Beauverd."
(6) Beauverd, G.: Monograph in Mémoires de la Société de Physique et d'Histoire Naturelle de Genève, xxxviii, fasc. 6 (1916).
(7) Soó, R. v.: Monograph in Fedde Repert. spec. nov. xxiv (1927).
(8) Name not complying with Article 30 of the International Rules of Botanical Nomenclature, 1930.

NOTES ON THE GERMINATION OF CORALLORHIZA INNATA.

By D. G. DOWNIE, Ph.D.

(Read 22nd April 1943.)

Corallorhiza innata Br. occurs throughout the northern hemisphere, but is extremely local in distribution and is therefore regarded as rare. It grows in swampy thickets and wet sandy copses. The plant is fairly readily observed in early summer when the flowering axis first appears, but it soon becomes overgrown with herbage and is then difficult to find even in known areas. This orchid is a complete saprophyte, yellowish to brownish in colour, leafless and rootless. Underground, there is the characteristic fleshy coralloid rhizome consisting of many short thick branches intricately interwoven, the branches terminating in round white apices. The plant is mycotrophic and the endophyte is present in abundance in the cortical cells of the rhizome. In Aberdeenshire the flowering axis appears towards the end of June, grows 6–7 inches in length and bears a few lax sheathing scales and 4–8 small yellow-green flowers. After pollination the ovaries increase considerably in size, become green in colour, then dark brown, and at maturity hang pendant from the axis. The seed consists of a loose brown membranous testa 0·7 mm. long, enclosing a small, centrally placed embryo 0·2 mm. × 0·1 mm. in size.

Previous experiments with the seeds of British orchids have demonstrated the fact that the germination capacity of the different species is very variable. Some species germinate readily in water at laboratory temperatures, e.g. *Coeloglossum viride* and *Orchis maculata*, others in sugar solutions, e.g. *Goodyera repens*, but in many cases successful germination has only been obtained by the stimulus of the endophytic fungus extracted from the roots or rhizomes of the parent plant. No record has so far been made of the germination of the seed of *Corallorhiza innata*.

In the first series of experiments attempts were made to germinate the seeds on various culture media without the fungus. In every case the results were negative. The seeds of this orchid will not germinate in water, nor in sugar solutions, nor in sugar solutions to which plant extracts have been added. So far, therefore, attempts at asymbiotic germination have failed.

To carry out the second series of experiments, *i.e.* the symbiotic series, the endophytic fungus had first to be isolated from the rhizome of the mature plant. There are two records of such an isolation, Wolff (4) who claimed the extraction of a species of Rhizoctonia, and Burgeff (1) claiming the isolation of a Basidiomycetous fungus recognised as such by the septate hyphae with characteristic clamp connections. Burgeff denotes this fungus as *M.R.* (*Coralliorhiza*) *innatae*. Neither investigator followed up his claim with the reintroduction of the fungus into the host, which in the opinion of the author is a critical step in the substantiation of any claim for the successful isolation of an orchid endophyte.

Of the endophytes so far isolated from British orchids by the author, all, with one exception, belong to the genus *Rhizoctonia*, a genus with septate hyphae, forming oidia at sporulation and of which the perfect stage is unknown. The one exception is the symbiont of *Corallorhiza innata*. The author agrees with Burgeff that the endophyte of this orchid is a member of the Basidiomycetes in that the hyphae of the fungus are septate and have clamp connections. The perfect stage is unknown. The fungus was extracted from segments of the rhizome in liquid cultures of potato extract. The growth of the fungus in this medium is very slow. Attempts to grow it in synthetic media consisting of the essential nutrient salts + sugar have not so far been very successful even when such substances as Aneurin (Vitamin B1) and Ascorbic acid (Vitamin C) were added. On the other hand the addition of Heterauxin (B-Indolyl-acetic acid) to the synthetic medium stimulated growth considerably, but not in excess of that obtained by the addition of potato extract. Meanwhile pure cultures are maintained in Pfeffer + potato extract (liquid).

In the symbiotic germination experiments the seeds were sown on glass wool in petri dishes and liquid media was used. The results of germination experiments with and without the endophytic fungus are shown in the table on page 382.

The sterilised seeds were sown on 10th October 1942, and the cultures were inoculated with the fungus on the same day. The fungus developed only in the culture medium containing nutrient salts + potato extract, and it was on this medium alone that germination took place. Growth of both the fungus and the embryos was very slow and by the end of nine months the embryos had only increased in length from 0·2 mm. to 1·6 mm. They had emerged from their seed coats and had developed into cream-coloured, pear-shaped protocorms bearing slender, projecting

GERMINATION OF *CORALLORHIZA INNATA.*

Media.	No Fungus.	*M.R.* (*Coralliorhiza*) *innatae.*	
	Germination.	Germination.	Growth of Fungus.
Distilled water . .	None	None	None
Barnes + dextrose . .	None	None	None
Pfeffer + dextrose . .	None	None	None
Pfeffer + potato extract .	None	Good	Good

epidermal hairs. Some of these small protocorms were treated with lacto-phenol and cotton blue and examined microscopically. It was observed that the fungus had entered the basal cells of the embryo and there formed the characteristic peletons or coiled hyphal stages commonly found in endotrophic mycorrhiza. Within the cells, the loosely coiled hyphae occasionally show the distinctive clamp connections.

The slow growth of both the embryo and the fungus suggests that the experimental medium lacks one or more essential constituent. Attempts are now being made to improve the medium with a view to stimulating the growth of both organisms.

SUMMARY.

The above experiments record the symbiotic germination of the seeds of *Corallorhiza innata*, and, by the entrance of the isolated fungus into the orchid embryo, establishes the fact that the normally associated endophyte is a member of the Basidiomycetes. A similar fungus was isolated by Burgeff (1) and named by him *M.R.* (*Coralliorhiza*) *innatae.* This name has therefore been adopted by the author until such time as the perfect stage of the fungus becomes known.

REFERENCES.

(1) BURGEFF, H. (1936): Samenkeimung der Orchideen, Jena.
(2) DOWNIE, D. G. (1940): Trans. Bot. Soc. Edin., xxxiii, 36–51.
(3) —— (1941): Ibid., xxxiii, 94–103.
(4) WOLFF, H. (1933): Jahrb. f. Wiss. Bot., lxxvii, 657–684.

SOURCE OF THE SYMBIONT OF GOODYERA REPENS.

By D. G. DOWNIE, Ph.D.

(Read 20th May 1943.)

In pursuit of further studies on *Goodyera repens* Br. information was desired regarding the distribution in the pinewood soil of its commonly associated symbiont *Rhizoctonia goodyera-repentis* Constantin. Any attempt to isolate this fungus directly from the different layers of humus material by cultural methods would have involved great expenditure of time and labour. An experiment was devised, therefore, which enabled one to obtain the same information in a simple, if indirect, manner. It has already been established that *Rhizoctonia goodyera-repentis* stimulates the germination of the seed of *Goodyera repens* providing some of the hyphae penetrate the basal cells of the embryo. This germination takes place freely in water at laboratory temperatures in the presence of the symbiont (Downie, 1940). It was thought, therefore, that if the pinewood soil to be examined was liberally sown with sterilised seed of *Goodyera repens*, any resultant germination would indicate the probable presence of the symbiont. Its presence could then be established definitely by the examination of the protocorms, the isolation of any included fungus and the identification of the endophyte in pure culture. Thus seed germination has been used in the experiments described below as the criterion for the determination of the presence of the symbiont in any particular organic stratum.

Experimental material was obtained from one area a few miles north of Aberdeen. This area consists of a small stand of pure pine 60–80 years old, and the forest soil consists mainly of pine-tree detritus. For the present purpose the soil is divided into two layers: (1) the surface litter composed of recently fallen needles, twigs, etc., and (2) the more compact humus in which the roots of the Goodyera plants become established. In a preliminary experiment the surface litter was further subdivided into its three obvious components, needles (bifoliar spurs), twigs, and cones. In all later experiments only the needles were used. As controls, withered needles shaken from the trees, and fresh green needles (1–2 year bifoliar spurs), were tested.

The four categories of the organic material were obtained as follows. The fresh needles were stripped from branches brought into the laboratory, the shaken needles were collected in an upturned umbrella in the field thus avoiding contact with the soil, the surface litter was lightly brushed off the soil from areas colonised with Goodyera plants and also from areas free from the orchid, and, finally, areas were cleared of all surface litter and of partially decomposed humus, and the more compact humus thus exposed was sampled. This humus material was collected from areas with and without Goodyera plants, and all fragments of roots and rhizomes were carefully removed. Collections in the summer of 1942 were made at six-week intervals, *i.e.* towards the end of July before leaf-fall or seed dispersal, at the beginning of September before leaf-fall and during seed dispersal, and in October at the time of the heaviest leaf-fall and after seed dispersal. The organic material was weighed out in 30-gm. lots and introduced into conical flasks previously sterilised. Sterile rain-water was added. The flasks were left in the laboratory for a varying period of two to three months before the seeds were introduced. Fruiting inflorescences were collected in September and the seeds introduced into all the flasks in October. All seeds were sterilised with calcium hypochlorite before sowing. Sowing operations continued over a period of two to three days, and an attempt was made to leave as many seeds as possible on the sides of the flasks to facilitate examination later. Flasks were examined at monthly intervals, but reports are drawn up on the results obtained four months after seed sowing.

The results of the preliminary experiment conducted in the summer of 1941 are shown in the first column of Table I. Many protocorms were noted in three of the flasks containing the "surface" needles, but no germination took place in the flasks containing "surface" twigs, cones, or the older compact humus material. On the assumption that germination takes place only where the appropriate endophytic fungus is present, it was deduced from the above that *Rhizoctonia goodyera-repentis* is confined to the surface litter and does not survive in the lower stratum of compacted humus. The most surprising result, however, was that obtained in the flasks set up as a control, *i.e.* the flasks containing the needles shaken from the trees. Every flask contained a very large number of germinating seeds, and the growth of the protocorms was vigorous and healthy, often surpassing that obtained in "surface litter" flasks. *Rhizoctonia goodyera-repentis* is generally recognised as a soil saprophyte, but its presence was not suspected on the withered

TABLE I.

GERMINATION RESULTS.

	Material.	1941.	1942.		
		Aug.	July.	Sept.	Oct.
Woodland Soil.	Surface Needles . .	3	5	5	3
	,, Twigs . .	0	. .	. .	. .
	,, Cones . .	0	. .	. .	. .
	Humus . . .	0	0	0	. .
Control.	Green Needles . .	. .	3	0	0
	Shaken Needles . .	6	5	6	3
	,, Twigs . .	0	. .	. .	. .
	,, Cones . .	0	. .	. .	. .

Six flasks were used with each medium, each containing 30 gm. of the appropriate material. The figures denote the number of flasks in which germination occurred.

needles still attached to the trees. Germination on the "shaken" needles might be due to some unknown factor, and the premise on which the original experiment was devised might then prove invalid. It was on this account that the experiment was repeated in more detailed form in the following year (1942), and this time fresh green needles were included in the examination. In every case the work of the previous year was confirmed. No germination was obtained on the compact humus (July and September), but successful germination occurred on both the "shaken" and the "surface" needles (July, September, and October). Added to these results is a record in the July flasks of germination on fresh green needles. This was not supported in the September and October flasks, but appeared again in a repeat experiment in December (Table II). In the flasks containing "shaken" and "surface" needles, the number of germinating seeds is very large and the growth of the protocorms excellent; on the other hand, only a very few germinations take place in the flasks containing green needles and further growth is poor.

The record of seed germination on a particular organic stratum is not sufficient in itself to establish the presence of *Rhizoctonia goodyera-repentis*. Non-mycorrhizal fungi present on the needles may, as suggested by Knudson (1922, 1924), change the external conditions of the organic material in such a way that soluble carbohydrates become available to the embryo and so stimulate germination; or again there may be other fungi associated with the bifoliar spur of *Pinus sylvestris* which can enter into mycorrhizal association with the embryo of *Goodyera repens* and effect germination. Many germinating seeds were taken from each of the flasks, treated with lacto-phenol and cotton blue, and examined microscopically. Regardless of the organic material on which germination had taken place, all the developing embryos, protocorms, and young plants examined showed the presence of an endophytic fungus. In small embryos, the hyphae occurred in loose coils in the basal cells, in the older protocorms about a third of the cells contain the peloton and digestion stages characteristic of endotrophic mycorrhiza. Bearing in mind the type of organic material under investigation, the results of this examination provide strong evidence in support of the symbiotic germination of the seed of *Goodyera repens* under natural conditions. A study of the few flasks containing fresh and withered needles in which no germination took place provided an equally strong argument refuting the theory of Knudson already cited. Many and varied are the species of fungi growing in these flasks: Myxomycetes, Phycomycetes, Ascomycetes, and Basidiomycetes have all been observed, yet none apparently have been able to bring about the requisite change in the organic material advocated by Knudson, because the seeds remain dormant.

In order to identify the fungus or fungi responsible for germination in the three categories of organic material in which protocorms had developed, isolation tests were performed. Two or three protocorms from each flask were treated in the recognised manner with 0·1 per cent. mercuric chloride and plated on potato dextrose agar. A fungus was isolated from these protocorms which corresponds in habit, colour of colony, morphological structure, and measurements of hyphae and oidia with that of a stock culture of *Rhizoctonia goodyera-repentis* isolated and maintained since 1939 from a root of a mature plant of *Goodyera repens*, and used in all previous experiments. The extractions of this fungus were readily and repeatedly obtained from the "surface-litter" and the "shaken-needle" protocorms. The protocorms which developed on the green needles were generally so small that they proved difficult to sterilise satisfactorily and one or two different fungi appeared in the isolation tests. However, two undoubted isolations of *R. goodyera-repentis* were obtained from the "green-needle" source. As some of these isolations were obtained while the seed of *Goodyera repens* was still viable, the cycle of investigation was completed by the successful germination of the seed on water-agar slopes which had been inoculated with members of the isolation series. It is therefore concluded that in the area under investigation *Rhizoctonia goodyera-repentis* occurs in or on the pine needles of the soil surface litter and also on green and withered needles attached to the pine tree. Further experiments are necessary before it can be stated categorically that this is the only species in the fungus flora of the pine needles of this area which can stimulate the germination of the seed of *Goodyera repens*, but it is certainly the dominant one.

The above experiments establish the fact that *Rhizoctonia goodyera-repentis*, the symbiont of *Goodyera repens*, survives only in the superficial layers of the forest soil. All its associations with the orchid must, therefore, be restricted to this zone. Evidence of this is forthcoming in the habit of the plant itself. All rhizomatous growth in the dense plant colonies is confined to surface layers. Mature roots do penetrate to the compact humus beneath, but histological evidence shows that the apical half of the root is always free from infection (Mollison, 1943). Dr. Mollison has also shown that the first infection of all roots takes place very soon after their emergence from the leaf sheath. On older axes these roots appear at the base of the green, leafy rosettes and on emergence must come in contact with the withered needles most recently deposited in the area. If the evidence for symbiotic seed germination is accepted, young protocorms should be found growing on the superficial layers. This is in accordance with all observed data on field-germinated protocorms of *Goodyera repens*.

It has been shown also that *Rhizoctonia goodyera-repentis* is present in some form on the green and withered needles attached to the tree. Three explanations of this are possible. First, that spores, derived from the fungus growing in the superficial layers of the woodland soil, are blown by the wind and lodge accidentally on the needles or between the scales at the base of the bifoliar spur. Second, that the fungus carries out a normal saprophytic life on the dead needles on the tree and continues this existence after needle-fall as long as there is sufficient food material available. Third, that the fungus is a parasite of green needles and pursues a saprophytic life for some considerable time after the death of the needle. With regard to the first suggestion, tree needles, both green and withered, were mainly taken from lower branches, so that in all likelihood many air-borne spores were present on the sampled material and this may be the simple explanation of the results. On the other hand, these air-borne spores would alight on tree-borne twigs and cones. But it will be seen (Table I) that no germination was obtained in flasks containing shaken material of this category. This suggests that the source of infection is to be found in or on the needles. Thus the other two possibilities must be considered. In an attempt to clarify the position as regards parasitism a small experiment was run in December. Needles from the three sources, on which the fungus survives, were surface-sterilised by washing well in 0·1 per cent. mercuric chloride for three or four minutes. They were then rinsed with sterile distilled water and introduced into flasks which later were sown with sterile seed of *Goodyera repens*. At the same time flasks with unsterilised needles of comparable material were set up as in all previous experiments. The results of this experiment are given in Table II.

TABLE II.

GERMINATION RESULTS.

Material.	Treatment.	Dec. 1942.
Green Needles . .	Non-sterile	1
,, ,, . .	Surface sterile	0
Shaken Needles . .	Non-sterile	6
,, ,, . .	Surface sterile	0
Surface Needles . .	Non-sterile	5
,, ,, . .	Surface sterile	2

Six flasks were used with each medium, each containing 10 gm. of the appropriate material. The figures denote the number of flasks in which germination occurred.

If *Rhizoctonia goodyera-repentis* is an endophytic parasite of pine needles, then the removal of superficial fungi should reduce competition, increase the growth of the endophyte in the flask, and enhance the chances of seed germination. Expected results would be similar for green and withered needles. On the other hand, if it exists on the needles as air-borne spores or as an epiphytic fungus it would be killed by the mercuric chloride and no germination would take place. The results support the second alternative. No germination occurs in flasks containing surface-sterile green or "shaken" withered needles. Germination only occurs in two out of six "surface-litter" flasks, a low proportion for this series. In these withered needles from the soil it may be presumed that the fungus has penetrated further into the tissues in search of food material and some of the hyphae have escaped the action of the fungicide. The conclusion is therefore drawn that *Rhizoctonia goodyera-repentis* exists on tree-borne needles of Scots Pine either in the form of air-borne spores or as an epiphytic fungus. While the second alternative must not be overlooked, the data strongly suggests that the fungus is present on both green and withered needles in the form of air-borne spores. Under moist conditions prevailing in the flask cultures the germination of the spores and the growth of the fungus proceeds. Withered needles prove to be the most satisfactory medium for the growth of the fungus, which in many instances develops abundantly on the walls of the flasks, and spores so profusely that it is readily recognisable. The moist, green needles, on the other hand, appear to form an unsuitable medium as evidenced indirectly by the low seed germination and poor growth of Goodyera protocorms, and directly by the absence of the fungus in any recognisable form on the wall of the flask. The chemical condition of the fresh organic material may be unsuitable to the growth of the fungus, or other fungi may be present on green needles which are inimical to the growth of *Rhizoctonia goodyera-repentis.* In whatever state the symbiont of *Goodyera repens* exists on Scots Pine trees, the knowledge that it is present in abundance on the bifoliar spurs before they are shed throws considerable light on the distribution of the fungus in the forest floor and on the chance of the colonisation of the soil by the orchid in question.

A small experiment on the distribution of *Rhizoctonia goodyera-repentis* in the pinewood from which experimental material was obtained was made in 1941. Twenty-four samples of surface litter were chosen at random throughout the wood. Surface needles were brushed from areas colonised with *Goodyera repens*, with the orchid and *Deschampsia flexuosa*, with the grass alone, and from areas colonised by a few scattered moss plants. The 30 gm. of material sampled from each area was divided into three flasks and treated as in the previous experiments. Germination was recorded on material from 16 areas, and results were independent of the type of area from which the needles had been brushed, *i.e.* areas, whether colonised with Goodyera plants or not, whether covered with vegetation or not, yielded germination, although blanks occurred in some of the areas. This experiment indicates a widespread distribution of the fungus in the surface litter, a result which is in accordance with the findings of the previous experiments.

SUMMARY.

1. *Rhizoctonia goodyera-repentis*, the symbiont of *Goodyera repens*, has been isolated indirectly from the soil of a Scots Pine wood. The fungus grows in the surface litter, but does not appear to survive in the older compact humus. All association of the orchid and the symbiont appears, therefore, to be confined to the surface layers.

2. The method of extraction used was dependent on the symbiotic germination of the seed of *Goodyera repens* on the natural organic material investigated.

3. Evidence is submitted of the presence of the symbiont on the bifoliar spurs of Scots Pine before shedding, a fact which is of importance in an understanding of the distribution of the fungus in the soil and the colonisation of the latter by *Goodyera repens.* The fungus is probably present on tree needles as air-borne spores.

4. Knudson's theory that orchid seed germination under natural conditions is brought about by the action of non-symbiotic saprophytic fungi on the organic substratum is challenged as a result of these investigations on the symbiont of *Goodyera repens*.

REFERENCES.

DOWNIE, D. G. (1940): On the Germination and Growth of *Goodyera repens.* Trans. Bot. Soc. Edin., xxxiii, 36–51.

KNUDSON, L. (1922): Non-symbiotic Germination of Orchid Seeds. Bot. Gaz., lxxvii, 212–219.

—— (1924): Further Observations on Non-symbiotic Germination of Orchid Seeds. Bot. Gaz., lxxix, 345–379.

MOLLISON, J. E. (1943): *Goodyera repens* and its Endophyte. Trans. Bot. Soc. Edin., xxxiii, 391–403.

GOODYERA REPENS AND ITS ENDOPHYTE. By JANET E. MOLLISON, Ph.D.

(Read 20th May 1943.)

I. INTRODUCTION.

In common with other orchids *Goodyera repens* Br. is mycorrhizic, but it differs from all other British species in being evergreen. The plant has long been recognised in Britain as especially characteristic of pinewoods in the north, where its rosettes of green leaves may be seen at all seasons. These ground rosettes are formed at the ends of branching rhizomes, which run horizontally in the loose superficial layer of leaf and moss litter commonly at a depth of one to two inches. All the roots are adventitious. In their early development they are protected by the sheathing leaf bases through which they emerge when about 2–2·5 mm. long. Fully grown roots may reach 2·5 mm. in diameter and vary in length from 2·5–8 cm., but they never penetrate into the hard soil below the leaf litter. They are densely covered with persistent root hairs. Absorbing hairs develop also on the rhizomes, occurring in small, isolated groups with no very regular arrangement. Buds occur just above the nodes of the rhizome. Some of them remain dormant, while others develop to form long slender shoots, which may reach the surface of the soil in their first season, producing small, sterile rosettes which persist during the winter. These rosettes renew their growth in the next season and in the following year they may form a flowering axis. In this way the plant is evergreen. After flowering the foliage rosettes die down, and sooner or later unflowered branches become severed from the parent rhizome to become independent plants. As a result of its ready vegetative propagation the plant is frequently seen forming colonies of considerable size. The species is thus characterised among British orchids both by its evergreen habit and by its free development of rhizomes. These features suggested that its mycorrhizic relationships might be of interest.

II. THE ENDOPHYTE.

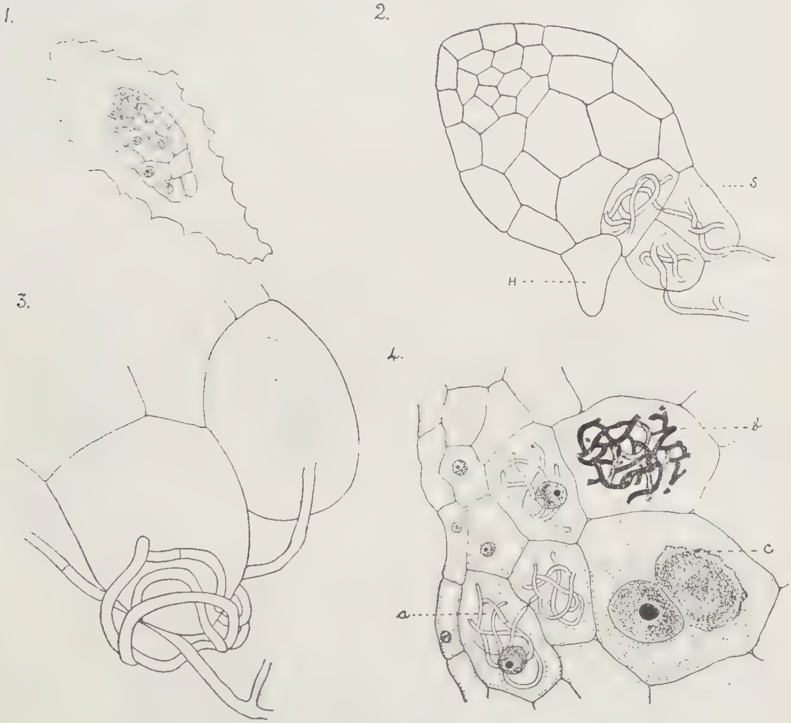
Constantin and Dufour (1920) were the first to isolate and identify the endophyte of *Goodyera repens*. Working with material from the

Forest of Fontainebleau they regularly obtained the same fungus in their isolation experiments and described it under the name *Rhizoctonia Goodyerae repentis* to distinguish it from Bernard's (1909) *Rhizoctonia repens* isolated from a number of different European orchids. More recently Curtis (1939) in America identified two fungi from *Goodyera repens* var. *ophiodes*, viz. *Rhizoctonia repens* and *R. borealis*. In material of *G. repens* from Aberdeenshire evidence has also been obtained of the presence of two endophytes, one of which, as reported by Downie (1940), agrees in its general structure with *R. Goodyerae repentis*, but the other is certainly not identical with *R. borealis*. The second symbiont is not of constant occurrence. It occasionally appears in association with the other endophyte and so far has never been found alone. Its mycelium as seen in root hairs consists of very slender septate hyphae, branching occasionally. The hyphae are about 1–2·1 μ in diameter and greyish-white in colour. Its appearance and behaviour inside the tissues of Goodyera are comparable to that of the normal endophyte and, like it, the pelotons of hyphae ultimately undergo digestion. This second fungus has so far not been isolated. In the experimental work recorded here, reference is always to the larger, prevailing endophyte isolated by Dr. Downie and used by her in recent experiments on the germination of Goodyera (Downie, 1940, 1941).

III. The First Infection and Subsequent Rate of Digestion of the Fungus in the Embryo.

The mycorrhizic state is known to be established at an early stage in germination, but little information is available about the distribution and persistence of the fungus in the adult plant. While seed can be successfully germinated on nutritive media containing sugar in the absence of the symbiont, young protocorms found in the field always show the presence of the endophyte, thereby suggesting that under natural conditions germination takes place symbiotically. In infected field protocorms, however, it is impossible to determine the exact time of entry of the fungus or the rate of its subsequent spread and digestion in the cells of the developing embryo. Experiments have been carried out with a view to settling these points using (1) seeds germinating in the presence of the endophyte and (2) young protocorms first grown aseptically and thereafter inoculated with the fungus.

Experiment I.—Seeds were sterilised with calcium hypochlorite and sown on agar slopes containing Pfeffer's mineral nutrient solution. The tubes had ten days previously been inoculated with the endophyte and a fine mycelial growth obtained before the seeds were introduced, so that most, if not all, of them were brought into close proximity with the fungal hyphae.



Figs. 1–4.—Stages in infection of seed. Fig. 1. L.S. of seed, ×95. Fig. 2. Young protocorm after infection, (*h*) absorbing hair, (*s*) suspensor cell, ×37. Fig. 3. Suspensor cells showing first infection of cell on right, ×95. Fig. 4. Older protocorm showing epidermal cells uninfected and cortical cells at different stages of infection, (*a*) coiled hyphae in outer cells of cortex, (*b*) beginning of digestion of hyphae, (*c*) digestion complete, ×250.

It may be recalled that the mature seed contains a small, ovoid, undifferentiated embryo furnished with abundant food material (fig. 1). Relatively large cells at the base distinguish the suspensor end from the much smaller cells forming the meristematic apex. As germination proceeds, the embryo swells, ruptures the delicate seed coat and gradually develops into a small, opalescent, pear-shaped body—the protocorm (fig. 2). Early stages of germination are marked also by the production of long, absorbing hairs from the epidermal cells of the protocorm.

In order to obtain data regarding the initial entry of the endophyte into the embryo, its subsequent intrusion and final digestion, observations were made at daily intervals after sowing. The progressive changes were recorded from samples of germinating seeds taken from a different tube each day, the material being stained and mounted in Cotton Blue and Lactophenol before examination. The results are given in Table I.

TABLE I.

ENTRY AND DIGESTION OF ENDOPHYTE IN GERMINATING SEED.

No. of Days after Sowing.	Suspensors Infected.	Cells above Suspensors Infected.	Body of Protocorm Infected.	Eiweiss-hyphen.	Amorphous Clumps.
1–4					
5	×				
6	×				
7		×			
8		×			
9		×			
10			×		
11–27				×	
28					×

It will be seen from Table I that invasion of suspensor cells of the embryo by the fungus occurred five days after sowing. Fig. 3 is an enlarged drawing of the suspensor region of a protocorm showing the first infection of one cell by the fungus.

At the end of a week the cells above the suspensors contained numerous hyphae, as seen in fig. 2. On subsequent days an increasing number of cells in the body of the protocorm were invaded and on the eleventh day the beginning of digestion was apparent in the presence of slightly swollen hyphae, which are very retentive of stains—the "Eiweisshyphen" of Magnus. This stage prevailed for some time, complete digestion of the fungus being observed at the end of four weeks from the time of infection.

Experiment II.—As already mentioned, protocorms found in the field are always infected, and it was thought worth while to repeat the foregoing experiment using young protocorms which had been grown aseptically on Pfeffer's solution + 1·5 per cent. dextrose + potato extract. These protocorms were transferred to agar slopes containing Pfeffer's solution which had been inoculated with the endophyte and were already showing a fine mycelial growth. While the general course of events was similar to that outlined above, the progress of the fungus was found to be much more rapid. Within 56 hours after transplanting, the endophyte had entered absorbing hairs of the protocorms and infection continued to take place much more freely through the hairs than by way of suspensor cells. After seven or eight days, hyphae had penetrated into the body of the protocorm, and "Eiweisshyphen" were observed on the ninth day. In a few instances digestion was complete at the end of a fortnight.

Goodyera seed will not germinate on a mineral nutrient medium alone, and it was thought of interest to establish just how soon invasion by the endophyte stimulated the growth of the embryo. Accordingly the length and breadth of embryos used in Experiment I were measured at different stages of infection, and the average of thirty was taken. These figures are shown in Table II.

Table II.

Measurement of Embryos at Successive Stages of Digestion.

	Uninfected Embryos.	Suspensor Cells Infected.	Cells above Suspensors Infected.	Cells in Body of Protocorm Infected.	Eiweiss-hyphen in one Cell.	Eiweiss-hyphen in many Cells.
Average Length	·21	2·2	·24	·27	·27	·29
Average Breadth in mm.	·11	·13	·13	·15	·16	·17

It is seen that embryos show a slight increase in size as soon as the endophyte invades the suspensor cells, and a small but steady increase accompanies the extension of infection. This stimulation to growth of the embryo occurs immediately on its infection and is apparent before the digestion of the fungus. Seed from the same cultures, which remained uninfected by the endophyte, showed no increase in size.

The protocorms used in Experiment II were fixed in Formalin Acetic Alcohol, microtomed and stained in Iron Alum Haematoxlin, and the material proved suitable for studying the general behaviour of the fungus up to the time of its digestion and for following the process of re-infection of the digestive cells. After penetrating the suspensor cells or entering through the absorbing hairs—the epidermal cells are never directly infected—the endophyte spreads inwards through the cortex until it is checked before reaching the central core of cells differentiating to form the stele of the protocorm. The infected region is, therefore, peripheral and as recognised by Magnus (1900) for some other orchids, it comprises two zones—an inner region of "digestive cells" and an outer zone of "host cells." In the "host cell" zone the fungus forms small pelotons (fig. 4, *a*); in the "digestive cell" zone the hyphae form larger pelotons at first but soon swell slightly and acquire a strong affinity for stains (fig. 4, *b*); ultimately they collapse and clump together to form a structureless brownish-yellow mass (fig. 4, *c*). In Goodyera, however, all the infected cells are potential "digestive cells," since the hyphae in the outer zone ultimately undergo digestion, but not until they have brought about re-infection of the cells of the inner zone. The cytology of digestion has been fully described by Burgeff (1936) for *Platanthera chlorantha*, and in Goodyera the process is essentially the same.

Re-infection of the digestive cells follows very rapidly upon the digestion of the first peloton, the source of infection being the active hyphae living in the cells of the outer zone. The hyphae of this second infection undergo digestion even more rapidly than those of the first, their remains forming a layer round the previously digested clump. In this way the contents of these cells sometimes have a stratified appearance. The number of re-infections of digestive cells in developing protocorms has not been determined, but it is possibly variable.

IV. Distribution of the Endophyte in the Adult Plant.

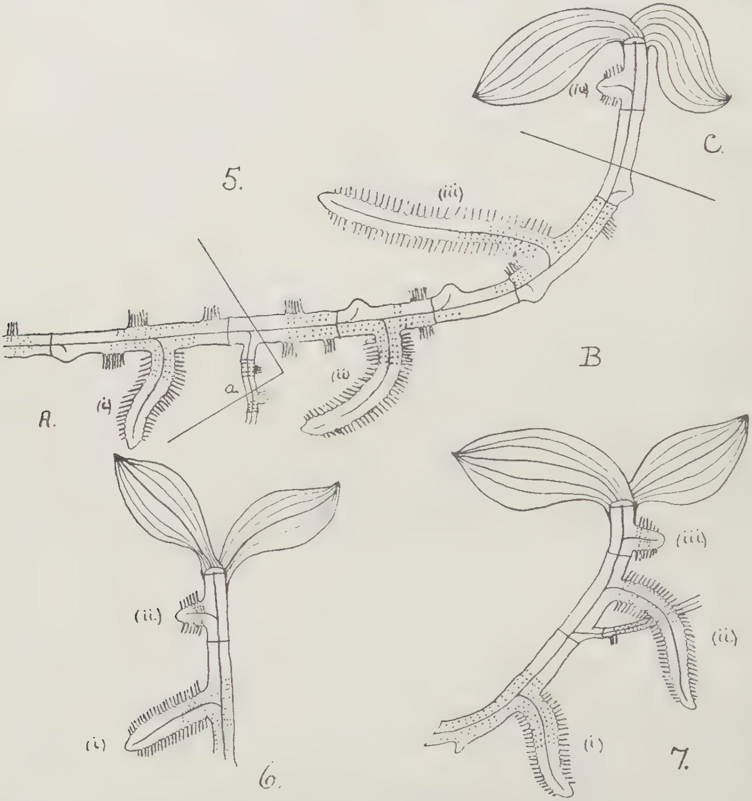
Anatomical investigations of complete field plants were made throughout the year in order, firstly, to determine the distribution and the appearance of the endophyte in the various plant organs at different seasons, and secondly, to study the problem of the infection of the young organs as they appeared on the plant. The problem of infection was of particular interest because the host plant is evergreen. As we have seen, embryos are infected at a very early stage. Does the endophyte thereafter maintain itself within the host, develop with the developing protocorm and young plant, invade new organs from within and remain a constant partner from embryonic stages to maturity, or is the spread of the endophyte within the host tissues limited and infection of new organs due to invasions of the saprophytic mycelium in the soil? If the infection of new organs, particularly roots, in *Goodyera repens* takes place repeatedly from an external source, then the sequence of events here would conform to that occurring in non-evergreen orchids.

Serial transverse and longitudinal sections of mature plants were made by hand and by microtome at monthly intervals throughout the year. The distribution of the fungus in these plants was noted and the following results obtained. Firstly, the rhizomes, roots, and lateral shoots are always in part affected; no mycelium is present in the leaves, either at the sheathing base or in the lamina; nor is the flowering axis ever invaded. Secondly, no marked changes were observed in the distribution of the fungus or in its intracellular behaviour throughout the year.

An idea of the distribution of the endophyte in the host plant may be obtained by reference to figs. 5, 6, and 7 which chart the position of the fungus in three specific examples and demonstrate results invariably obtained in many other plants. The shaded regions indicate areas of invaded cells, and it may be seen at once that these areas are not continuous even in the older parts of the plant. All roots are infected at their bases with the exception of one very young root (fig. 5, iv). The invaded cells occupy the basal $\frac{1}{3}$ $\frac{1}{2}$ of each root and rarely extend nearer the apex than this. Not only, then, are the meristematic cells of the root uninfected, but the cells in a considerable region behind the apex remain immune. The rhizome in the region of an infected adventitious root may have its cortical cells completely invaded (fig. 5, i) or only partially invaded (fig. 5, ii). There are also apparently distinct zones of immunity in the mature rhizome. These occur wherever there are dormant axillary buds, which arise just above a node. The whole rhizome may remain uninfected in these regions (fig. 5, A) or occasionally the mycelium spreads from an infected internode across the node on the side remote from the axillary bud and invades the internode beyond (fig. 5, B). Other parts of the axis invariably free of the endophyte are the youngest part of the rhizome bearing the rosette of green leaves and the flowering axis of mature plants.

The non-continuous distribution of infected areas in the rhizome, together with the frequent confinement of infection in the root to the basal half, points to an inability of the fungus to travel far in the plant. This restriction might be due to one or both of the following causes. Firstly, some factor may be developed in the host cells in the region of attack which prevents further penetration, or secondly, the hyphae may lose vitality in their passage from cell to cell, preventing an indefinite invasion from an initial point of infection.

With regard to the intracellular condition of the endophyte throughout the plant, reference may be made to fig. 5 in which three



FIGS. 5–7.—Diagrams of portions of the rhizome. Stippled areas represent occurrence of the endophyte.

zones of varying age have been delimited. In zone A, the oldest part, all the mycelium had been digested; no trace of hyphal filaments could be found; yellow-brown clumps in the cells of the shaded regions are the only indication that mycelium had been established there. In zone B the endophyte is seen in all the various stages of its life within the host. In the majority of infected cells there is a central yellowish-brown clump surrounded by the recognisable fungal filaments of a subsequent invasion. In a few cells in the older part pelotons may be seen in the outer cortical cells and the number of such cells increases in the younger parts of root and rhizome. Zone C, consisting of the youngest part of the rhizome and one young root and the terminal rosette, has no mycelium in its cells at all.

V. Infection of the Mature Plant.

(*a*) *Root.*—It can be seen at once from the isolated position of infected roots that the invasion of the tissues takes place repeatedly from the external mycelium in the soil. The roots (fig. 6, ii and fig. 7, ii and iii) obviously could not have been infected from within, as considerable areas of rhizome absolutely devoid of hyphal filaments occur both around and below the infected root bases. Young roots are first observed as swellings at or near the nodes in the basal region of the rosette. At first they are protected from the exterior by the bases of the amplexicaul leaves, and no root examined at this stage has shown any sign of infection. Later the root pierces the leaf sheath and enters the soil. Almost immediately the root hairs are invaded by hyphae in the humus and this is rapidly followed by the formation of a zone of infected cells in the basal region of the young root. Roots less than 3 mm. long may or may not be infected, but the majority of roots which exceed 3 mm. in length are found to be already invaded by the fungus.

(*b*) *Rhizome.*—While the root is invariably infected by hyphae invading it from the humus, the rhizome has two distinct sources of infection. Firstly, hyphae from the cortical cells at the base of an infected root may spread into the neighbouring cells of the rhizome (fig. 6, i), and secondly, hyphae in the soil may invade rhizomatous hairs and pass from there to establish pelotons in the cortical cells of both primary and secondary axes. In older rhizomes it is often difficult to determine the exact source of infection. Three invaded areas in the rhizome may be seen in fig. 5, i, ii, iii. In each case infection has probably arisen in part from invaded rhizomatous hairs and in part from hyphae in neighbouring root cells. In young shoots, on the other hand, the second source of infection is often clearly demonstrable. Fig. 5, *a*, shows a young shoot, which has not yet developed any adventitious roots. Two infected areas are depicted, each area being clearly separated from the other and from the nearest infected zone of the parent rhizome by areas quite devoid of hyphae. Obviously the infection of the young shoot was brought about by the invasion of the rhizomatous hairs by mycelium from the soil.

(*c*) *Further Details of Infection.*—Hyphae, which are comparable by measurement to the hyphae-forming pelotons in the cortex, are frequently found both in root hairs and rhizomatous hairs. The actual penetration of the hair by external hyphae has been more difficult to establish because the delicate hairs are often partly destroyed when the roots and rhizomes are separated from the humus and also because many hyphae pass out of the plant again through the root hairs. Actual penetration of the wall is often encountered, but whether by an incoming or outgoing hypha is not always discernible. A marked constriction of the hypha is apparent at the point of penetration of the cell wall and a very slender hyphal tip grows through, only to resume its normal diameter at the other side. No swelling in the form of an appressorium has been noted. Hyphae growing down the root hair may establish a loose coil in the basal part of the cell. From there they penetrate through the exodermis and outer layer of cortical cells to the second and inner cortical layers, where they form the characteristic pelotons. The exodermis and outermost layer of cortical cells apparently serve largely as passage cells to the interior, and the number of places where hyphae can be traced from a root hair through these two layers to the interior is very small. Successful hyphae on reaching the "host-cell" zone branch actively and spread radially from cell to cell forming small pelotons in the second and third cell layers of the cortex and much larger ones in the inner regions of the cortex. This invasion into the tissues is continued until checked three or four cell rows from the endodermis. These three innermost layers are never attacked. Soon after the middle cortex is invaded, the hyphae forming the large, dense pelotons in these cells are seen to collapse, clump together, and apparently undergo some form of digestion. As in most orchids, therefore, two zones are soon established in the cortex of infected regions of root and rhizome; an outer zone, one or two cell layers deep, in which healthy hyphae in loose coils may be seen, and an inner, more extensive zone, where the cells are larger and the hyphae in various stages of digestion.

VI. Discussion.

Under natural conditions it may be assumed that the endophyte associated with Goodyera occurs as a soil saprophyte. The constant occurrence of the endophyte in field protocorms and the results of experiments described by Downie (1940), in which she obtained germination of Goodyera in the presence of the endophyte in water alone, strongly suggest that germination in the field is initiated by fungus infection. The experiments described in the present paper demonstrate that this infection takes place remarkably soon after seeds or uninfected protocorms have been brought into association with the mycelium of the endophyte. The ensuing process of digestion can be completed within twelve days after the first entry of the fungus. No previous record is known on this rate of digestion except that of Burges (1939), who, working with *Orchis incarnata*, found that the new roots became infected about April and that digestion of the fungus was apparent about the end of May—a much longer period than in the case of Goodyera. The observations made on *Orchis incarnata* were made on field plants, however, where the whole process may occupy a longer time than it does under culture conditions in the laboratory.

The fact that the final stage in the life of the fungus leading to its complete digestion should be reached earlier, when it infects protocorms rather than seeds, is probably due to the fact that the initial physical and chemical changes accompanying germination had already been completed, giving conditions which, though at first favourable to the rapid spread of the endophyte, at the same time furnish the embryo with a more immediate mechanism of control over the invader.

With regard to this point it was observed in the test tubes, where seed was sown, that many seeds become completely parasitised by the endophyte, in contrast to those in which protocorms were sown—the protocorms apparently being able to resist this completely parasitic invasion.

The mode of infection of Goodyera and the behaviour of the fungus after penetration agree essentially with what has been observed in other orchids. Infection is possibly more general in Goodyera, where all roots and shoots are infected, whereas it is quite usual to find some roots uninfected in other species. Most orchids are infected seasonally in early summer, when the new roots develop, but from the first infection of the embryo of Goodyera its association with its endophyte is continuous throughout the year, periodic re-infections by mycelium in the humus of each new root and of most young shoots taking place at all times.

The non-continuous distribution of infected areas in the rhizome, together with the frequent confinement of infection in the root to the basal half, points to an inability of the fungus to invade tissues indefinitely. This might be due to one or both of the following causes. Firstly, some factor may be developed in the host cells in the region of attack which prevents further penetration, or, secondly, the hyphae may lose vitality in their passage from cell to cell, preventing an indefinite invasion from an initial point of infection.

In its radial distribution the mycelium never invades the cells immediately round the endodermis. In this region, in young roots and rhizomes, chloroplasts are present, and it has been noted on different occasions by other workers that hyphae avoid areas where chlorophyll is developed.

The fungus also keeps a certain distance behind apical growing points and never invades meristematic cells. The absence of fungus from these areas does not explain all the gaps in distribution in the rhizome, nor the restriction in quite old roots of the fungus to the basal half or less of the root. It is necessary, then, to consider the second possibility that the failure of the fungus to spread throughout the plant may be due to a loss of vitality of the fungus in the orchid.

In older tissues even in the "host cells" the mycelium is eventually destroyed, but this does not explain the failure of the hyphae to continue their invasion of new cells unless there is a change in the metabolism of the fungus itself which restricts its growth, similar to the "staling" of fungus cultures. Burges (1939) demonstrated the loss of vitality of hyphae in the "host cells" of old roots of *Orchis incarnata* by removing apparently healthy pelotons from the outer cortex on to agar plates, where they showed poor growth compared with that shown by similar hyphae from young roots. It would seem that the stimulation to growth of the fungus on its first entry into the plant is very soon succeeded by the first stages of digestion in the inner cortical cells, and though in the outer the mycelium is at first immune from the destructive forces in the plant, there must be a loss of vitality which prevents the mycelium spreading indefinitely.

VII. SUMMARY.

1. Seeds of *Goodyera repens* sown on cultures of *Rhizoctonia Goodyerae repentis* become infected by the fungus 5 days after sowing.

2. Growth of the embryo starts immediately on the penetration of suspensor cells by the hyphae and before the digestion of the fungus.

3. Evidence of fungus digestion by the orchid is seen 28 days after sowing.

4. Asymbiotically germinated protocorms of *Goodyera repens*

transferred to a culture of *Rhizoctonia Goodyerae repentis* are infected in 56 hours and digestion follows from the 14th day onwards.

5. In adult plants roots and rhizomes are invariably infected by the symbiont. Aerial parts remain uninfected.

6. Evidence of successive infections of the orchid plant is demonstrated by the occurrence of interrupted zones of infection in the rhizome.

7. Re-infection of the rhizome takes place through absorbing hairs and each new root is infected by mycelium in the humus.

8. Areas free from infection in the orchid are the meristems of the root apex and of lateral buds and cells where chlorophyll is developed. A loss of vitality of the fungus after existing for some time inside the plant is suggested to explain further areas in root and rhizome which remain uninfected by the endophyte.

This work was carried on in the Botany Department of the University of Aberdeen, and I have to express my thanks for the assistance and facilities granted to me.

VIII. REFERENCES.

BERNARD, NOEL (1909): L'évolution dans la symbiose. Ann. Sci. Nat., Sér. 9, ix, 1.

BURGEFF, H. (1936): Die Samenkeimung der Orchideen. Jena.

BURGES, A. (1939): The Defensive Mechanism in Orchid Mycorrhiza. New Phyt., xxxviii, 273.

CONSTANTIN, J., and DUFOUR, L. (1920): Sur la Biologie du *Goodyera repens.* Rev. Gén. de Bot., xxxii, 529.

CURTIS, JOHN T. (1939): The Relation of Specificity of Orchid Mycorrhizal Fungi to the Problem of Symbiosis. Amer. Journ. Bot., xxvi, 390.

DOWNIE, D. G. (1940): On the Germination and Growth of *Goodyera repens.* Trans. Bot. Soc. Edin., xxxiii, Part I.

—— (1941): Notes on the Germination of Some British Orchids. *Ibid.,* xxxiii, Part II.

MAGNUS, W. (1900): Studien an der endotrophen Mycorrhiza von *Neottia Nidus avis* L. Jb. wiss. Bot., xxxv, 205.

ECOLOGICAL NOTES ON LACTUCA ALPINA BENTH. (MULGEDIUM ALPINUM LESS.) IN SCOTLAND. BY J. GRANT ROGER, B.Sc.

(Read 20th May 1943.)

As a native plant in Britain *Lactuca alpina* (*Mulgedium alpinum*) appears to exist at present only upon Lochnagar in Aberdeenshire and on the adjacent hills of Angus. It is extremely local in its distribution, and the few colonies which survive are apparently rarely seen by field botanists. In order, therefore, that some facts relating to the ecology of the species may be available to those interested, the following observations are here recorded.

The Blue Sow-thistle, as the plant is commonly called, grows on Lochnagar at elevations between 3300 ft. and 3600 ft. on the great granite precipices of the Eastern Coire. Here it was discovered by George Don in September 1801. At least two colonies are well established in places which can be reached only by hardy climbers, and it seems very probable that it was one of these colonies which Don, in his indefatigable enthusiasm, encountered one hundred and forty-two years ago. Only in summer and early autumn should one expect to find the more elevated plants without digging in snow, but throughout July and August even the specimens at over 3500 ft. are, as a rule, quite uncovered, and are able to flower freely. The exposure is north-easterly.

In Angus the species has a lower but wider altitudinal range, being recorded from 1600 ft. up to *c.* 2700 ft. The latter figure refers to the approximate height of a flourishing colony on the north-facing cliffs at the head of Caenlochan Glen. Smaller groups have been observed in Canness Glen and in the Glen of the Doll.

The higher habitats on Lochnagar and Caenlochan are well sheltered by steep acid-igneous rocks. The soil consists of granitic gravel intermixed with humus. Typically, there is a considerable amount of peaty material held firmly around the stout rhizomes of the plants; indeed the surrounding soil has obviously a very good moisture-retaining capacity compared with that found on the adjacent screes and ridges. Only where a sufficiently good accumulation of soil is possible can *Lactuca alpina* survive, and whenever the falling of rocks exposes the habitat to denudation and strong drying winds the species is doomed.

As regards the flora associated with *L. alpina* at Caenlochan and on Lochnagar the following species were noted: *Lychnis dioica* (to 3500 ft. on Lochnagar), *Oxalis Acetosella*, *Alchemilla alpina*, *Sedum roseum*, *Epilobium angustifolium* (3300 ft. on Lochnagar), *Galium saxatile*, *Gnaphalium norvegicum* (Lochnagar only), *Hieracium* spp., *Euphrasia officinalis*, *Rumex Acetosa*, *Oxyria reniformis*, *Luzula sylvatica*, *Anthoxanthum odoratum*, *Agrostis tenuis*, *Deschampsia flexuosa*, *D. caespitosa*, *Dryopteris dilatata*, *Blechnum Spicant*, *Polytrichum piliferum*, *P. commune* (in alpine form), *Rhacomitrium lanuginosum*, *Cladonia rangiferina*, *C. cornuta*.

On several remote ledges the *Lactuca* is very closely associated with *Luzula sylvatica* and *Oxalis Acetosella*, and these, along with a few other species, may form a community of plants recalling the flora of moist shaded places in the lowlands.

The rhizomes, from which the flowering stems arise year after year, are very tough and firmly rooted. They are commonly about $\frac{3}{4}$ inch in diameter and heavily marked with the scars left by old annual shoots. The roots extend horizontally rather than vertically.

Under the broad leaves, which arise from the lower portion of the stem, there is good shelter for small herbs such as *Oxalis Acetosella*. Non-flowering leafy shoots are common, particularly in the case of fairly large colonies where upwards of 50 stems appear annually. The flowering and flowerless stems vary in height from several inches to over 4 ft., but the average height for flowering stems is about $2\frac{1}{2}$ ft.: whereas most of the purely vegetative stems are under 2 ft.

In the higher situations the taller plants are, of course, rare, although at 2700 ft. a specimen of 4 ft. 4 in. was measured last year. That particular plant had 17 leaves on the stem below the flowers and there were 50 well-formed flower-buds. Its stem was very strong and firm below—about $\frac{3}{4}$ inch in diameter a little above the procumbent rhizome. The largest leaf measured was 10 in. long and $6\frac{1}{2}$ in. broad across the base of the terminal lobe.

On the upper parts of the plant there are glandular hairs, and the upper portion of the stem tends to be reddish purple. Lower down the stem is usually pale green and bears fine white hairs distributed rather sparsely.

It is normally during July that *L. alpina* flowers on our hills, but the time of flowering varies considerably according to elevation and seasonal conditions. Even on the larger racemes only a few flowers are displayed at one time and these are only fully open in bright weather. The petals become mauve as they wither.

Since the few remaining colonies of the Blue Sow-thistle in Scotland are beyond the reach of animals that might desire to eat the rather succulent foliage, rain and wind are perhaps the chief enemies of the surviving plants. Many of the finest specimens are badly damaged by the heavy rainstorms that are common upon the mountains in late summer, but it seems fairly certain that the weather alone will not prevent the survival of this interesting, but now very rare, member of our native flora.

THE ALGAL VEGETATION OF CERTAIN BOGHALL FARM SOILS.

By E. WYLLIE FENTON, M.A., D.Sc.

(Read 20th May 1943.)

Previous work investigating the origin of the algae in the streams and ditches of Boghall Glen (Fenton, 1936, 1937, 1938 iii, 1939) showed that these algae were not derived from Boghall Glen soils (Fenton, 1938 iv, 1940 vi). Soil occupied by certain well-known vegetation types (Fenton, 1933) gave a very poor algal flora (Fenton, 1938 iv, 1940 vii). This lack of algae in Boghall Glen soils suggested comparison with soils on Boghall Farm for both arable and grass land. The present paper is the result of this investigation.

Soil samples were taken from the top three inches of soil. All leaves, stems, and roots were removed. These soil samples were cultured in petri dishes, and also in milk bottles as previously described (Fenton, 1939). The petri-dish method consisted of placing soil in petri dishes, keeping the soil moist and exposing to a good northern light in the laboratory. For purposes of identification of algae, samples were taken from, and just below, the surface of the soil in the petri dishes. Both the milk-bottle method and the petri-dish method were used so as to act as a check on each other. The milk-bottle culture develops algae very well, but it is of course more artificial than the petri-dish method. It may be argued that the petri-dish method is neither natural nor normal. That is true, but beyond the continuance of a high degree of moisture (not abnormal at certain periods of the year), and at times a higher than normal temperature, it is as near field conditions as is possible in a laboratory. In order to follow field conditions as far as circumstances permitted, the petri-dish cultures were utilised for results. Only very minor differences were noted between the two methods of culture.

"H.P." was soil from a recently dug and cultivated plot near Caerketton. The soil taken from the "Gardens" site (Fenton, 1933) is from soil presumed to have been out of cultivation for at least 250 years. "Leips" is soil from the old arable land on the site formerly occupied by Leips Farm in Boghall Glen (Fenton, 1933). The soil samples were collected just after the turf was ploughed up. "D.A." is soil from a plot in the Demonstration Area in the plane below the entrance to Boghall Glen (Farm Guide, 1939). The "D.A." soil was included since it has been highly cultivated and manured for several years. The results are shown in Table I.

At the same time soil samples were obtained from certain pastures and arable fields for comparison with the results obtained in Boghall Glen and the Demonstration Area. Upper Lambing Field East and West, and Lower Lambing Field, were—at the time of the experiment—permanent pastures. House Park is a rotation field which has now been a pasture for a few years. Kimming Hill is a rotation field (1939) in root crops, and Seafield is in grass following a cereal crop (Farm Guide, 1939), previous to this it was a pasture.

As work progressed it became evident that a list of algae found was not important, but that the algae forming a dominant community were. In other words, the problem had to be viewed from the ecological aspect. There were distinct phases in the algal development in the cultures before they finally settled down to a definite type. The type of dominant community in the vegetation was utilised for comparing the soils. In Tables I and II only algae of importance in the community are recorded. The tables record the presence of a genus or group of algae in the locality listed. "X" indicates the presence of the alga. "T" means a trace, or that the alga was scarce. "d" means that the algae are members of a dominant algal community. It will be noted that in Table I only the Demonstration Area shows the presence of Myxophyceae. In Table II it is obvious that only Seafield (–) and Upper Lambing Field (E) show no Myxophyceae and a trace respectively. Algae other than Myxophyceae are more common in the soil of the farm fields than in the soil of Boghall Glen.

It was noted that those soils which on culturing failed to develop a Myxophycean community usually produced a large number of fern prothalli. In the other soils they were comparatively rare or absent. The ferns which developed were identified as *Lastrea Filix-mas* by Mr. W. Young, to whom I am indebted for the fern identifications. Generally algal growth was plainly visible as a green covering in the petri dishes. Where Myxophyceae were plentiful, that peculiar acid-earthy smell was very pronounced.

DISCUSSION.

Soil algae have been investigated in a very thorough and detailed way at Rothamsted Experimental Station by Bristol (1916, 1919, 1920, and 1927). But at Rothamsted the algae were cultured on

TABLE I.

Field.	Pr.	M.	O.	A.	N.	Cy.	Ph.	Pl.	U.	B.	N.	V.
H.P.	X	X	T	..	..	..	..	Xd	..	Td	..	Xd
Gardens	X	X	..	..	..	..	..	Xd	..	..	..	..
Leips	X	X	..	..	..	..	..	Xd	..	Td	..	..
Demonstration Area	X	X	Xd	Xd	Xd	Xd	Xd	X	..	X	X	X

TABLE II.

Upper Lambing Field (W)	X	X	Xd	Xd	Xd	Xd	..	X	..	..	..	..
Upper Lambing Field (E)	X	X	T	T	..	..	..	Xd	Xd	..	..	..
Lower Lambing Field	X	X	Xd	Xd	Xd	Td	Td	X	X	..	..	..
House Park	X	X	Xd	Xd	Xd	..	Xd	X	X	T	X	..
Kimminghill	X	X	Xd	Xd	Xd	Xd	..	X	X	..	..	..
Seafield (+)	X	X	Xd	Xd	..	Xd	Xd	X	X	..	..	..
Seafield (−)	X	X	..	..	..	..	..	Xd	Xd	Td	..	..

X = Algae present.
T = Trace.
d = Member of dominant algal community.

Pr = Moss protonema.
M = Moss.
O = Oscillatoria.

A = Anabaena.
N = Nostoc.
Cy = Cylindrospermum.

Ph = Phormidium.
Pl = Pleurococcus.
U = Ulothrix (incl. Hormidium).

B = Bumilleria.
N = Nodularia.
V = Vaucheria.

a special media and not on the soil wherein they occurred. Another point of importance is that these investigations were concerned chiefly with the algal flora and not with algal communities. Now the flora of any area is not generally a key to the soil, climatic, and biotic conditions. but the dominant vegetation usually is. The writer has always felt that detailed and special culture methods to isolate all algae present do not give a true picture of the important algae occurring in soils. It is not the isolated individuals or species that are of importance but the communities, and in particular those communities which dominate the algal vegetation. To achieve conditions as near as possible to those normally occurring in nature is essential. This has been rightly stressed in an article by Neilson Jones (1940). Discussing soil fertility he says: "An outstanding difficulty is the impossibility of reproducing in pure cultures of soil organisms the conditions present naturally in the soil, and the danger of drawing deduction from such cultures as to what the behaviour of any organism will be in the soil, where it exists as a member of a mixed soil population in a continually shifting environment."

Samples drawn from the same sources as those given in the Tables were also taken during the winter, to check up on any variation due to summer sampling. The same phases or successions occurred, except that Bumilleria, though present, was not prominent. What does affect algae very markedly is the drying out of the soil during a drought. This has also been pointed out by Stokes (1940).

A glance at Table I shows that the soil from the Demonstration Area had not merely a good flora, but contained a high proportion of Myxophyceae. There were three distinct phases of development in this soil culture. First, the moss protonema and moss stage, which was not always too well marked. Second, the Chlorophycean phase, when Bumilleria (Heterokontae) is often present and in a few cultures temporarily dominated other algae; and lastly, the Myxophycean stage. The Myxophycean phase, the concluding one —which continued for many months—is very complete, and suggests an ecological (or agricultural) climax. A similar succession occurred in cultures of soils from farm fields except Upper Lambing Field E. and Seafield (–). Besides the algae listed many others occurred; in fact D.A. soil showed a very strong resemblance in flora to that recorded by Bristol Roach (1927). This is not surprising, since in the Demonstration Area both manuring and cultivation are very intensive. If next the H.P. soil is considered, it will be noted that its chief characteristic is its algal poverty. Only a trace (T) of

Myxophyceae occurred, but there was a trace of Bumilleria. These algae may of course have been introduced into the soil with the implements used in breaking up and cultivation. The soil had never—on record—been previously cultivated. Leips soil was cultivated at least 250 years ago: it is now again in cultivation (1940), but here again the algal poverty of the soil is very obvious. This also applies to the "Garden" soil. It is evident that with the lapse of cultivation and manuring the algal vegetation is not only meagre but completely changes and ceases to be dominated by a Myxophycean community. The results shown in Table II are very interesting in comparison with those in Table I. Lower Lambing Field has been in permanent pasture for many years and was probably the best pasture on the farm (ploughed up in 1940). It was in very good condition, and that is clearly reflected in the algal vegetation which is distinctly Myxophycean. It is not so good as House Park or Kimming Hill (rotation fields), or the Demonstration Area. House Park and Kimming Hill are both the Myxophycean type of algal vegetation. It was much more evident in the cultures than can be deduced from Table II. It will be noticed that a trace of Bumilleria was found in the soil of House Park, and that Nodularia was also recorded. Seafield requires some explanation since the two soils show such amazing differences. Seafield (+) was soil taken where some time previously a cow pat had fallen, and the vegetation showed the usual dark green colour. The soil Seafield (−) is from the eastern end, where it is poor with a considerable amount of peat. It is obvious that Seafield (−) soil is almost identical with a Boghall Glen soil, apart from a slight trace of Bumilleria, probably due to cultivation. On the other hand, Seafield (+) soil closely resembles the other good arable soils of the Farm, as Table II shows. Manuring, particularly organic (nitrogen) manuring, is evidently an important factor in determining the nature of the algal vegetation.

It has generally been assumed that there must be a good supply of nitrogen in order that Myxophyceae may flourish. This is clearly demonstrated in the two Tables. The best soils are those cultivated and manured, and their cultures all showed a dominant Myxophycean algal community. The three chief dominant types in the Myxophyceae were Oscillatoria, Anabaena, and Nostoc. They never occurred in a pure condition, but mixed. Their frequency of occurrence was usually in the order already mentioned, and their ability to compete with each other seemed to follow the same order. As might be expected, the milk-bottle cultures showed more rapid changes and fluctuations, doubtless associated with the micro-organisms present, and the ease with which this could be transmitted through the water covering the soil. Whether this is of universal application is another matter, but the results from the petri-dish cultures are quite evident and can be correlated with the pH of the soil and its fertility. The method used is too cumbersome and lengthy to be of any technical value for assessing soils, but it offers an interesting comparison with other methods, and leads to similar conclusions.

Recently Oscillatoria spp. has been found to an increasing extent in Boghall Burn just below the recently cultivated land of Leips. There can be only one explanation of this appearance and slow but steady increase of Oscillatoria. The drainage from the cultivated and manured soil is carrying away and stimulating this alga to assume a more prominent position among the other algae recorded. As Oscillatoria has not previously been recorded in Boghall Burn, either above or below the Leips area, and records are available for the last ten years, no other explanation seems possible.

Allison, Hoover, and Morris (1937) state that Myxophyceae are of considerable importance in the maintenance of soil fertility. If the results they report with one species (*Nostoc muscorum*) are typical, it would appear that those Myxophyceae reported to be capable of fixing nitrogen thrive best in nearly neutral or alkaline soils, preferably partly shaded, and where moisture is abundant. This is in general accord with the Myxophyceae vegetation of Boghall Farm and Glen. The importance of carbon dioxide and acidity is also stressed. In Boghall Glen it would thus appear that the low pH of the soil is one of the chief limiting factors for Myxophyceae. This has also been shown by John (1942).

After more than eighteen months of culture, Upper Lambing Field East soil slowly but gradually developed Myxophyceae, mostly Oscillatoria, but the Myxophyceae never reached a dominant position. This late developed Myxophycean growth might not occur under field conditions, and only the higher temperature and steady supply of moisture over a period of more than a year accomplished this change in algal vegetation. In spite of this change Chlorophyceae were still plentiful and dominant. In recently cultivated and heavily manured soil from a plot in Boghall Glen, traces of Myxophyceae were found. Soil from the Leips area developed a rather meagre Myxophycean vegetation after cultivation and carrying a good potato crop. These facts suggest that it requires some time for the algal vegetation of a soil to change and settle down to any particular condition such as has been described.

There is little doubt that the Myxophycean dominance is bound up with bacterial activity as well as that of other micro-organisms. In the poorer soils it was noted that there were distinct traces of fungi, but that there was much less protozoan activity. As previously pointed out (Fenton, 1940 vi), Myxophyceae are intimately bound up with bacterial and protozoan activity, and until the way is prepared the Myxophyceae cannot attain a dominant position. It may well be that what is here designated the Myxophycean dominance is probably merely a part of the development of a much greater mixed community of organisms (Picken, 1937). A point of some importance is that the temperature of an unheated laboratory is on the average higher than the open-air temperature of soils. In the winter the temperature of a laboratory, when heated, is far higher. This probably induces an unusual activity both in micro-organisms and the Myxophyceae (Fenton, 1940 vi), perhaps approaching conditions in the soils of warmer climates. It is interesting that Sing (1939), working on the soils of Paddy fields in India, found Myxophyceae very frequent near the roots of the crops, even at considerable depths below the surface of the soil. This suggests stimulation by micro-organisms in the soil. Fourteen species of Myxophyceae and seventeen of Chlorophyceae are recorded. Milk-bottle cultures with an aqueous mineral solution were used, and not tap or stream water. Species of Calothrix, Nostoc, Phormidium, and Oscillatoria were most common. The early appearance of moss protonema, then Chlorophyceae, and Myxophyceae remaining to the last, is in complete agreement with Boghall cultures. Work in America by Allison, Hoover, and Morris (1937) is largely in agreement with Boghall results, and with Sing (1939). Recent work by Bharadwaja (1940) still further emphasises the importance of Myxophyceae in Indian soils. Nostoc and Anabaena often occur in considerable quantity, and fix atmospheric nitrogen. The fixation of nitrogen by Myxophyceae has been dealt with by De (1939).

Results obtained from cultures of Boghall Farm soils are not necessarily of wide or even general application. Only further investigation with soils of different types, from different localities, and even from different climates will decide if there is a general algal vegetation parallel in agricultural and other soils.

Summary.

The dominance of groups or genera of Myxophycean algae is found to be correlated, among other factors, with the degree of soil fertility.

The algae considered are those forming an algal community.

Boghall Glen soils are poor in Myxophyceae, but are dominated by a Chlorophycean community.

Poor and then permanent pastures rank next in the importance of a Myxophycean community.

Arable or well-cultivated land ranks highest, as judged by the dominance of a Myxophyceae community.

Before reaching the stage of Myxophycean dominance, there are definite phases of succession: moss protonema, mosses, Chlorophyceae, and finally Myxophyceae.

The Myxophycean community seems to be a biotic or agricultural climax.

References.

Allison, E. A., Hoover, S. R., and Morris, H. G. (1937): Physiological Studies with the Nitrogen-fixing Alga *Nostoc muscorum.* Bot. Gaz., xcviii, 433–463.

Bharadwaja, Y. (1940): Aspects of the Myxophyceae. Indian Science Congress Association. Nature, cxlv, 519.

Bristol, B. M. (1916): On the remarkable Retention and Vitality of Moss Protonema. New Phytol., xv, 137–143.

—— (1919): On the Retention and Vitality by Algae from Old Stored Soils. New Phytol., xviii, 92–107.

—— (1920): On the Alga Flora of some Desiccated English Soils. Ann. Bot. Lond., xxxiv, 35–80.

Bristol Roach, B. M. (1927): On the Algae of Some Normal English Soils. J. Agri. Sc., xvii, 563–588.

De, P. K. (1939): The Rôle of Blue-green Algae in Nitrogen Fixation in Rice Fields. Proc. Roy. Soc. London, cxxvii, 121–139.

Fenton, E. Wyllie (1933): The Vegetation of an Upland Area (Boghall Glen, Midlothian). Scot. Geogr. Mag., xlix, 331–354.

—— (1936): The Periodicity and Distribution of Algae in Boghall Glen (Midlothian). Scot. Nat., pp. 143–148.

—— (1937): Algae Studies from Boghall Glen (Midlothian), II. Scot. Nat., pp. 115–122.

—— (1938 iii): Algae Studies from Boghall Glen (Midlothian), III. Scot. Nat., pp. 87–92.

—— (1938 iv): Algae Studies from Boghall Glen (Midlothian), IV (Soil Algae). Scot. Nat., pp. 165–172.

—— (1939): Algae Studies from Boghall Glen (Midlothian), V. Culture Series No. 1. Scot. Nat., pp. 50–54.

—— (1940 vi): Algae Studies from Boghall Glen (Midlothian), VI. Culture Series No. 2. Edin. and East of Scot. Col. Agric.

—— (1940 vii): Algae Studies from Boghall Glen (Midlothian), VII. Culture Series No. 3. Edin. and East of Scot. Col. Agric.

Guide to Boghall Farm (1939): Edinburgh and East of Scotland College of Agriculture, pp. 12–19.

John, R. P. (1942): An Ecological and Taxonomic Study of the Algae of British Soils, I. Ann. Bot. Lond., New Ser., vi, 323–349.

Jones, W. Neilson (1940): Some Biological Aspects of Soil Fertility. Nature, cxlv, 411–412.

Picken, R. E. L. (1937): The Structure of Some Protozoa Communities. J. Ecol., xxxv, 368–384.

Sing, R. N. (1939): An Investigation into the Algal Flora of Paddy Field Soils of the United Provinces of India. Ind. J. Agri. Sc., ix, 55–77.

Stokes, J. L. (1940): The Influence of Environmental Factors upon the Development of Algae and other Micro-organisms in Soil. Soil Science, xlix, 171–184.

OBSERVATIONS ON INDIAN CARDAMINE. By
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(Read 17th June 1943.)

The need of detailed study of the genus *Cardamine* was emphasised by the late Father E. Blatter, S.J., who drew my attention to the anomalous nature of the number of stamens and of the glands, the variable characters of the leaves, and other morphological differences and particularly to the different forms of the widely distributed species *Cardamine hirsuta* L. and *Cardamine subumbellata* Hook. f. Examination of the Indian material at Kew, at the British Museum, the Fielding Herbarium, Oxford, the Royal Botanic Garden, Edinburgh, and Calcutta, shows that there has been considerable confusion. The Indian species of *Cardamine* do not appear to have been dealt with in sufficient detail by O. E. Schulz in his exhaustive and illuminating "Monographie der Gattung Cardamine" published in Engler's Botanische Jahrbücher, xxxii, 280–623, 1903. Realising the scope for further study of the Indian members of the genus, I have made an attempt to give in the following pages a fuller account of them.

I am indebted to Sir Arthur Hill, Sir William Wright Smith, and Mr. Ramsbottom for giving me every facility to examine the type specimens in the herbaria of the Royal Botanic Gardens, Kew and Edinburgh, and the British Museum (Natural History), London, and last but not least to Dr. J. M. Cowan for his suggestions and criticisms.

GENUS CARDAMINE.

Annual, biennial, or perennial herbs, occurring either as solitary specimens or in groups in shady areas or moist hill slopes. Underground stem bulbiferous, stoloniferous or scaly, creeping or caespitose; aerial stem erect, ascendent, diffuse or flaccid, simple or branched, glabrous, pubescent or hairy. Leaves simple, pinnate or pinnatisect, alternate or rarely verticillate, inflorescence racemose or subcorymbose, often without bracts or rarely bracteate near the apex. Flowers erect or nodding, white, pale purple, mauve, pale violet or pale yellow; sepals nearly equal at the base, oblong or ovate; petals clawed, obovate or subspathulate; stamens 4–6, filaments subulate, erect; anthers oblong, base somewhat sagittate, pollen grains shortly elliptic, more or less minutely armed, with 3 longitudinal ribs; gynophore short; ovary cylindrical, 4–40 ovulate, ovule uniseriate, oval or orbicular; style often filiform, short or long, rarely absent, somewhat attenuate; stigma simple, more or less bilobed; pods (siliquae) narrow or broadly linear, elongate, compressed, sometimes tapering at both ends, placenta often thick, rarely subulate, valves 1–3 nerved, more or less distinct, opening elastically, septum membranous, more or less hyaline. Seeds compressed, elliptic or somewhat quadrate-oblong, cotyledons irregularly plicate or spirally involute, rarely reflexed along the margin, radicle rarely very short.

The genus *Cardamine* was founded by Linnaeus in 1735. His diagnosis in Syst., ed. 1, 1735, was elaborated by Bentham and Hooker in Genera Plantarum, i, 70, 1842. Five other genera: (1) *Dentaria* Linn., Syst., i, 1735; (2) *Pteroneurum* DC., Syst., ii, 269, 1821; (3) *Heterocarpus* Phil. in Bot. Zeit., xiv, 641, 1856; (4) *Cardanoglyphos* Schlect. in Linnaea, xxviii, 472, 1856; (5) *Ghinia* Bubani, Fl. Pyren., iii, 158, 1901, are considered synonyms.

About 330 species of *Cardamine* have been recorded up to the present time; of these 116 species have been dealt with critically in O. E. Schulz's "Monographie der Gattung Cardamine." The species of *Cardamine* are distributed over the North and South temperate regions and over the higher mountain ranges in the tropical regions of both hemispheres. Asia has 100 species (China 45, Japan 27, India 13, Siberia-Turkistan-Persia-Caucasus cum Malay Archipelago 14); South America, 80 (Chile 60, the rest 20); N. America, 55; Europe, 50; Australia, 11; New Zealand, 8; Africa, 8; other regions, including the Pacific and the Atlantic Islands, 18.

Thirteen species have been enumerated from India. These do not include *Cardamine Inayatii* O. E. Schulz and *Cardamine loxostemonoides* O. E. Schulz, forms of *Cardamine hirsuta* Linn., which is a cosmopolitan species, distributed throughout India from the sea-level to an elevation of 5400 m. in the Himalayas. The table on page 418 shows the altitudinal succession of the different species in India.

KEY TO THE SPECIES.

A. Leaves simple: not deeply lobed or pinnatisect:
- (i) Leaves sessile, ½ amplexicaul, lanceolate . . . . *C. violacea*
- (ii) Leaves long-stalked, cordate or subcordate . . . *C. circaeoides*

B. Leaves compound:

- I. Leaves trifoliolate or bifoliolate, irregularly lobed, slightly or deeply toothed:
  - (*a*) Leaves large, 2–3-foliolate:
    - (iii) Leaflets large, smooth, membranous, ovate or cuneate, deeply crenate or irregularly deeply incised or lobed, along the margin; raceme flowering densely from the base to the apex subtended by a simple or 2-foliolate or 3-foliolate leaf (bract) *C. Smithiana*
  - (*b*) Leaves small, 3-foliolate:
    - (iv) Leaflets small, hispid or hairy, broadly ovate, crenate or crenate-serrate; raceme short, flowering closely towards the apex. *C. africana*
    - (v) Leaflets very small, obovate or obovate-oblong, 3-lobed, lobes obtusely rounded, flowers aggregated towards the apex. *C. trifoliolata*
- II. Leaves many-jugate, pinnatisect:
  - (vi) Leaflets nearly all suborbicular, ovate, or obliquely cuneate, irregularly lobed and crenate, stamens generally 4, herbs with younger parts covered with hispid hairs . . *C. subumbellata*
  - (vii) Leaflets lower orbicular or ovate, toothed and angled; upper narrower, oblong, simple or lobed, stamens generally 6, herbs with few hairs or naked . . . . *C. hirsuta*
  - (viii) Leaflets ovate, oblong or lanceolate, obtusely 3–5-lobed, auricled, auricle of stem-leaves sagittate . . . . *C. impatiens*
  - (ix) Leaflets of radical leaves orbicular ovate, of cauline leaves linear oblong, entire . . . . *C. pratensis*
  - (x) Leaflets often with the basal pair at the axil of the leaf adhering to the stem, entire or sinuate, ovate, oblong or rounded, subcordate, more or less trilobate . . . . *C. Griffithii*
  - (xi) Leaflets linear, oblong, sublobed, angled or entire . *C. elegantula*
  - (xii) Leaflets ovate, elliptic-lanceolate, serrate sometimes more or less deeply incised, acute or acuminate . . . *C. macrophylla*
  - (xiii) Leaflets ovate, cuneate or obliquely crenate, broadly elliptic, oblong, deeply widely crenate, broadly rounded at the apices *C. ovata*

ALTITUDINAL SUCCESSION OF CARDAMINE SPECIES IN INDIA.

Name of the Species.		Western Himalayas.	Eastern Himalayas.	Peninsular Hills.
1	*C. violacea*	4300 m.	×	×
2	*C. circaeoides*	×	1600 m.–3300 m.	×
3	*C. Smithiana*	×	2900 m.	×
4	*C. africana*	×	×	1500 m.–4300 m.
5	*C. trifoliata*	×	2700 m.–4000 m.	
6	*C. subumbellata*	×	×	830 m.–2100 m.
7	*C. hirsuta*	1000 m.–5400 m.	0–5000 m.	660 m.–2500 m.
8	*C. impatiens*	1300 m.–2100 m.	2000 m.–4700 m.	1700 m.–4000 m.
9	*C. pratensis*	2700 m.	×	×
10	*C. Griffithii*	×	3300 m.–4700 m.	×
11	*C. elegantula*	×	2166 m.	×
12	*C. macrophylla*	2500 m.–4000 m.	3300 m.–5300 m.	×
13	*C. ovata*	2100 m.	×	×

1. **Cardamine violacea** (Don) Wallich.

Robust, erect herb, 1–2 m. tall, stem simple, somewhat fistulose, thick, sparsely pilose towards the apex. Leaves 3–15 cm. long, 8–20 mm. broad, sessile, $\frac{1}{2}$ amplexicaul, lanceolate, tapering to the tip, acuminate, dentate, puberulous on the upper surface or on both the surfaces. Inflorescence racemose. Flowers 12–24 mm. long and nearly as much in diameter, deep violet, pedicellate, pedicel 8–12 mm. long; sepals up to about 8 mm. long, ovate subacute, oblong, 5-nerved, margin hyaline; petals intensely violet, obovate-cuneate, subemarginate; stamens, inner 11 mm. long, outer 9 mm. long; anthers 2 mm. long, oblong; glands distinct; style elongate, 5–7 mm. long; stigma 0·5 mm. broad; pods 2–6 cm. long on a thickened pedicel (1–2·5 cm. long), tapering at both ends, valves with a central midrib, concave. Seeds 2–3 mm. long, 1–2 mm. broad, oval or oblong, brown, more or less plicately striated.

Habitat: Temperate region of the Himalayas (Gossain Than (Nepal), Wallich's Catalogue No. 4782; Tapchet, Nepal, 4300 m., 1928, Lall Dheroj).

2. **Cardamine circaeoides** Hook. f. et Thomson.

Annual or perennial herb. Stem 15–40 cm. high, erect, more or less branched, very sparsely minutely pubescent, or nearly glabrous. Leaves 1·5–3 cm. long, 0·8–2·5 cm. broad, cordate, obtuse, sinuate, toothed, lower lobes rounded, leaf-stalk slender, in upper leaves 6 mm. long, in lower as long as 6–7 cm. Raceme subcorymbose, few-flowered. Flowers small, white, pedicellate, pedicel 4–6 mm. long, open flowers 3–5 mm. across; sepals 4, 2–3 mm. long, $\frac{1}{2}$-$\frac{3}{4}$ the length of the petals; petals 4, 4–6 mm. long, white, oblanceolate, cuneate; stamens, inner as long as or slightly longer than the petals; style equal to or longer than the petals; stigma large, broad, globose; pods on short horizontal or erecto-patent pedicels, 7–10 mm. long, narrow, linear 15–30 mm. long; seeds 1 mm. long, 6 mm. broad, oblong, brown.

Habitat: In moist woods throughout the Eastern Himalayas from Sikkim to Bhutan and to Bhamo in Upper Burma.

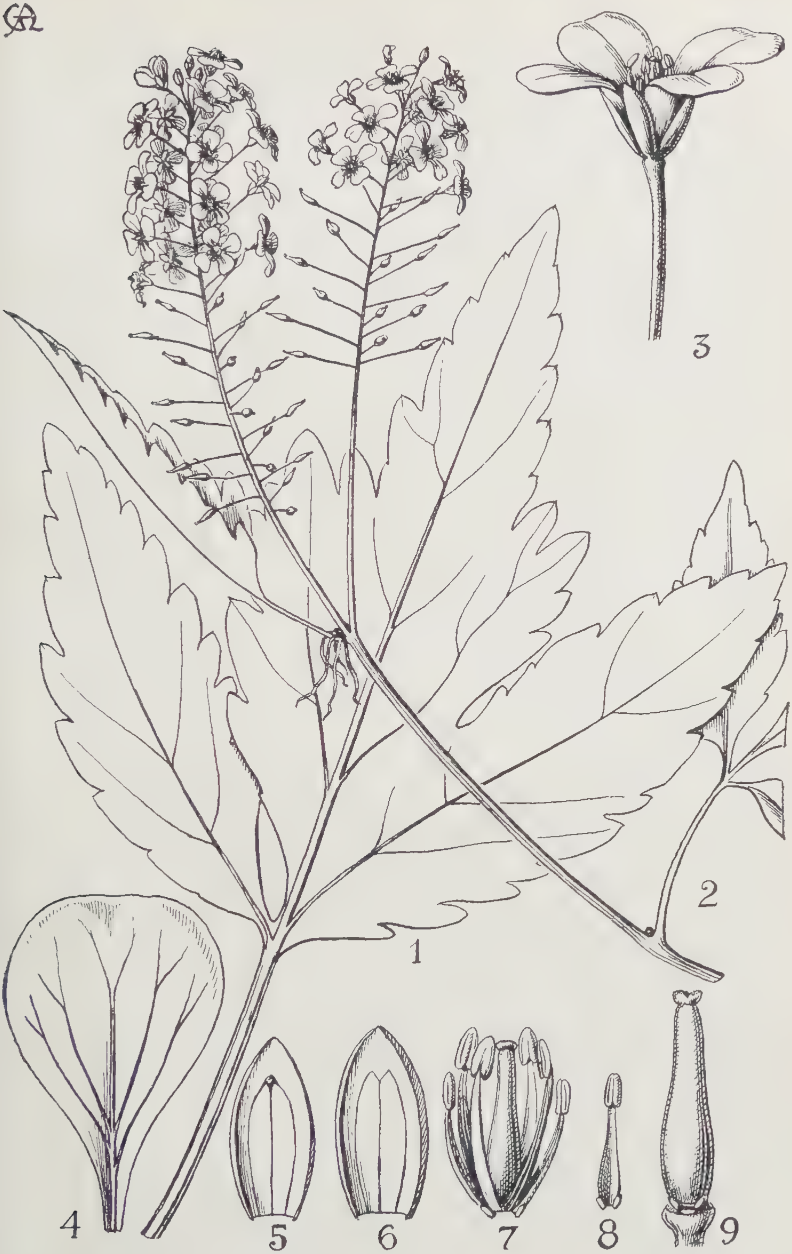
3. **Cardamine Smithiana** K. Biswas in Journ. Bot., lxxvi (1938), 22.

Annual or perennial, tall, erect herb. Leaves 5·5–13·5 cm. long, 3–9 cm. broad, often trifoliolate, sometimes bifoliolate or on the upper part at the base of the raceme simple, unifoliolate, petiolate; petioles 1–4 cm. long; leaflets 5–11·5 cm. long, 1·5–5 cm. broad, ovate or ovate cuneate, elliptic-oblong or elliptic-oblanceolate, terminal leaflets sometimes 2–3-fid, margin deeply crenate-serrate or irregularly lobed, lobes more or less acuminate, at the apices, membranaceous, glabrous on both the surfaces. Raceme 6–9·5 cm. long, terminal, developing at the axil of simple, 2-foliolate or 3-foliolate smaller leaves similar to the foliage leaves, solitary or in pairs or sometimes three. Flowers crowded, uniformly arranged ($\frac{2}{5}$ phyllotaxy) from the base to the apex of the raceme about 6 mm. long, up to about 10 mm. across, pale mauve, pedicellate, pedicels 5–7 mm. long; sepals 5, 2–3 mm. long, 1–2 mm. broad, oblong, concave on the ventral side with 3–4 parallel nerves all converging towards the apex into a brown glandular structure (which is rarely absent), pale green on the dorsal side, margin white or hyaline, smooth, obtuse, or acute at the apices; petals 5, 5–6 mm. long, 4–5 mm. broad, pale mauve, obovate, cuneate, broadly rounded at the apex; stamens 6, 4 interior, 4–5 mm. long, 2 exterior, 3–4 mm. long, each of the outer two stamens subtended at the base by single or a pair of glands; glands 0·5–0·8 mm. long; anthers 1 mm. long, oblong, 0·5–0·8 mm. broad; pistil 3 mm. long, ovary about 2 mm. long, 0·5–0·8 mm. broad, style 1 mm. long, stigma globose, capitate; pod pedicellate, pedicels narrow, erecto-patent or sub-horizontal, sometimes somewhat pendent.

Habitat: Donga La, Tibet, growing as dense jungle, at an elevation of 2900 m. Type No. 324, collected by F. Ludlow and G. Sherriff, 25th July 1933.

4. **Cardamine africana** Linn.

Perennial herb; about 15 cm. to $\frac{2}{3}$ m. tall, somewhat decumbent or erect, simple or sparingly branched upwards, sparsely hispid or hairy, rarely nearly glabrous. Leaves rather crowded towards the base, almost aphyllous above; trifoliolate, long-petiolate, petiole 2–9 cm. long, 5–16 cm. long; leaflets broadly ovate or rounded at the base, more or less irregularly sharply crenate, acute or acuminate at the tips, sessile or petiolulate; petiolule up to 2 cm. long, blades of leaflets 1·5 mm.–7 cm. long, 7 mm.–2·5 cm. broad, sparsely pubescent or nearly glabrous on both the surfaces, more densely along the nerves, hairs hyaline; raceme few-flowered, somewhat corymbose towards the apex. Flowers very shortly pedicellate; pedicel 0·5–1·5 mm. long, much prolonged in fruiting stage, dull white, 3–4 mm. rarely up to 5 mm. long, 2–5 mm. across; sepals 4, 2–3 mm. long, oblong, nearly half the size of the petals; petals obovate, oblong, 4–6 mm. long; stamens 6, 4 inner longer, 2 outer



C. Smithiana K. Biswas. Fig. 1. Leaf, natural size; 2. Flowering spray, natural size; 3. Flower, ×4; 4. Petal, ×8; 5. Outer sepal with gland, ×8; 6. Inner sepal, ×8; 7. Gynaceum and stamens, ×8; 8. Short stamen with glands at the base of filament, ×8; 9. Mature pistil, ×8.

shorter, filaments smaller than the petals, 3–5 mm. long; style 1 mm. long; pistil up to half the size of the petals, cylindric, ovary 8–16-ovulate, stigma globose, flat, pedicel of the fruit 4–8 mm. long. Pod 2·5–4 cm. long, erect or erecto-patent, crowded or sublax. Seeds brown, oblong, slightly compressed, somewhat depressed at the centre, 2 mm. long, 1·5 mm. broad, 0·5 mm. thick.

Habitat: In Southern India, abundant in the Nilgiri Hills.

5. **Cardamine trifoliolata** Hook. f. et Thoms.

Annual, 10–18 cm. high, erect, slender herb, with a creeping rootstock; stem simple or very sparingly branched at the base. Leaves remote, glabrous or sparsely pilose near the base; the radical and cauline leaves similar, long-petioled, trifoliolate, petiole variable, 8 mm. to 8 cm. long, leaflets generally obovate, the terminal often 3-lobed, the lateral sometimes narrowly ovate or oblong, bilobed, rarely entire, lobes rounded or obtusely pointed, shortly petioled, petiolule 5–7 mm. long, blades of lateral and terminal leaflets widely variable in dimensions, 5–12 mm. long, 2–12 mm. broad, upper leaf lamina of the narrower leaflets 8–11 mm. long, 2 mm. broad, sparsely pubescent on the upper surface, nearly smooth underneath; raceme short, few-flowered. Flowers 7–8 mm. long, up to about 8 mm. across, pale lilac, pedicel filiform, 5–6 mm. long; sepals 4, nearly half the size of the petals, 2–4 mm. long, ovate; petals 5–8 mm. long, obovate-cuneate, subtruncate at the apices, rarely clawed, pale lilac or almost white; stamens 6, 4 interior about two-thirds of the length of the petals, about 5 mm. long, 2 exterior about 3 mm. long; anthers 0·75 mm. long, oblong; pistil cylindrical, smooth, ovary 8–12 ovulate, style rather thick, about 1 mm. long, somewhat attenuated, ending in a more or less globose or subulate stigma. Capsule 12–15 mm. long, erect, pedicellate, pedicels 4–5 mm. long. Seeds minute oval about 1 mm. in diameter.

Habitat: In moist woods of the Eastern Himalaya from Sikkim to Bhutan, ascending from about 2500 to 4000 m. Flowering in June to July, fruiting in autumn.

6. **Cardamine subumbellata** Hook. f.

Perennial or annual, diffuse or corymbose branched herb, about 20–30 cm. tall, sparingly hairy with younger parts and flower-buds often with spreading hairs, branches not tinged with purple but pale greenish. Leaves petiolate, pinnate, with 5–7 leaflets, 4–7 cm. long, with the petiole, terminal odd leaflet larger; petiole 6–22 m. long; leaflets subsessile, ovate or suborbicular, usually narrowly cuneate at the base, irregularly crenate or lobed, sparingly hairy, 20–25 mm. long with the petiolule, 8–12 mm. broad; radical and cauline leaves similar, radical leaves not forming a rosette. Inflorescence few-flowered, at first somewhat corymbose, later racemose. Flowers pedicelled, pale yellow; pedicels short, slender, 1–2 mm. long; sepals oblong or narrowly oblong, obtuse, with long bristly hairs; petals oblong, yellow or pale yellow, 1·5–2 mm. long; usually only the 4 inner stamens present, the outer 2 abortive or often represented by two outer glands, filaments with the anther 2 mm. long, sometimes slightly larger but usually the same length as the petals. Pistil elongate, narrowly linear, slightly shorter than the stamens, style short, stigma globose; capsule pedicellate, pedicel 3–8 mm. long; mature fruits somewhat crowded towards the apex of the raceme, linear-lanceolate, slightly compressed, 1·5–2·6 cm. long, often with sparse white hairs, bursting along the median suture. Seeds 4–8, oval or oblong, brown, hardly compressed, 1·5–2 mm. long, 1–1·5 mm. broad, 0·4–0·5 mm. thick.

Habitat: In the shaded and moist woods of the montane zone in the Deccan, abundant throughout the Nilgiris, Eastern and Western Ghats, up to an elevation of 2100 m.

N. A. Dalzell in his "Contributions to the Botany of Western India," published in Hooker's Journ. of Botany and Kew Gardens Miscellany, iv, 294, 1852, describes *C. subumbellata* as a variety of *C. hirsuta* and notes the chief distinguishing characters. In a footnote, Sir Wm. Jackson Hooker writes: "In his MS. Mr. Dalzell had considered this a new species, and called it *C. Belgaumensis*. He rightly compares it with Dr. Hooker's *C. corymbosa* in Ic. Plant., t. 686, from Campbell's Island; but after an examination of numerous specimens of *C. hirsuta* from various parts of the world, Dr. Hooker is compelled to unite *C. corymbosa* as a variety to *C. hirsuta*; and the present state, with corymbose flowers and fruits (for the inflorescence does not *generally* elongate into a raceme even in fruit), along with specimens from other parts of India, Australia, etc., may come under the same variety." J. D. Hooker subsequently raised this variety to the status of a species and describes it in Fl. Brit. India. It is purely an Indian species confined to the hills of Peninsular India, occurring mainly in the subtropical and subtemperate montane regions of the Nilgiris and Western Ghats, and is particularly abundant in the moist shady areas of Pauchgani and Mahabaleshwar.

7. **Cardamine hirsuta** Linn.

Annual or biennial, glabrous, suberect or decumbent herb. Stem 8–50 cm. tall, erect, simple or diffuse and much branched. Leaves petioled, not auricled, radical, imparipinnate bearing 5–13 leaflets; leaflets orbicular ovate or more or less cuneate, irregularly toothed, angled or more or less lobed, 5–15 mm. across; cauline leaflets gradually narrower, lanceolate, narrowly oblong or obovate, toothed, angled or irregularly lobed, obtusely rounded at the apices, very variable in shape and size, petioled or subsessile, petiole up to 5 mm. long, entire, blade 5–25 mm. long, 1–15 mm. broad, sometimes broader, three-lobed. Inflorescence racemose or subcorymbose. Flowers many, somewhat crowded towards the apices, 3–5 mm. across, white; sepals sometimes purplish, about half the size of petals, 2–2·5 mm. long, oblong, obtuse; petals white, obovate-cuneate, rounded at the apex, up to 5 mm. long, 1–2 mm. broad; stamens 6, inner four larger, outer two smaller, rarely the two outer abortive, 2–3 mm. long, anthers 0·5–8 mm. long; pistil cylindric, style subulate, stigma capitate, ovary many-ovuled. Capsule pedicellate, erecto-patent, elongate, cylindric, somewhat compressed, 15–25 mm. long, 1 mm. broad, pedicel 3–10 mm. long. Seeds 6–12 on either side of the septum, subquadrate-oval or oblong, 1 mm. long, 0·5–0·8 mm. broad, brown.

Habitat: In moist shady places, as a weed spreading throughout India and Burma from the plains (in cold season) to the temperate hills of both the Western and the Eastern Himalayas, ascending up to 5400 m., extending from Kashmir to Upper Burma. It is common also in the hills of peninsular India, ascending up to 2500 m.

J. D. Hooker and T. Thomson in their contribution entitled "Praecursores ad Floram Indicam," published in the Journ. of the Linnean Society (Bot.), v, 146, 1861, distinguish the following three varieties:—

"var. α. Caule suberecto, foliolis ovato-cordatis lobulatis, siliquis sublonge acuminatis.

"var. β. Caule diffuso, foliolis ovatis sinuato-lobulatis, siliquis acutis, stylo brevi.

"var. γ. Caule diffuse ramoso, foliolis, ut in α, siliquis acuminatis, stylo elongato—*C. oxycarpa* Boiss."

William Jackson Hooker and A. Walker-Arnott, in their British Flora (8th edition), 1860, reduced *C. flexuosa* With. and *C. sylvatica* Link to *C. hirsuta* L. In the description they, however, recognise two forms: (i) smaller, pedicels erect, stamens 4, style very short;

(ii) larger, pedicels patent, stamens usually 6, style as long as the breadth of the pod. In an earlier work William Withering in his Arrangement of British Plants, iii, 578, 1796, describes as two separate species *C. hirsuta* and *C. flexuosa*. He evidently separates the forms having 6 stamens from those having 4 stamens, and raises them to the status of species. According to J. D. Hooker and T. Anderson in the Flora of British India, i, 138, 1875, *C. sylvatica* of Linnaeus and *C. oxycarpa* of Boissier are two varieties of *C. hirsuta*.

Cooke, in his Flora of the Presidency of Bombay, i, 30, 1903, combines the characters of *C. hirsuta* and *C. subumbellata*. Collett in his Flora Simlensis, pp. 32–33, 1902, mentions *C. sylvatica* and *C. oxycarpa*. In the Botany of Bihar and Orissa, p. 27, 1921, Haines records *C. hirsuta* var. *sylvatica* from Ronebi, Bihar, and Orissa. Haines rightly distinguishes *C. hirsuta* having six stamens. E. Blatter in his Beautiful Flowers of Kashmir, i, 35–36, 1928, describes the two varieties of *C. hirsuta* as two separate species as adopted by H. Collett in his Flora Simlensis. J. S. Gamble in his Flora of the Presidency of Madras, i, 37–38, 1915, records *C. hirsuta*.

Schulz maintains the specific position of *C. corymbosa* Hook. f. and *C. flexuosa* With. But careful scrutiny of the type specimens and of all the sheets under these two names in Herbaria leads me to consider these to be different forms of *C. hirsuta*. I prefer, therefore, to reduce these two species to *C. hirsuta* Linn.

Examination of the sheets of *Cardamine* in the Herbaria at Kew, the British Museum, Edinburgh, Oxford, and Calcutta, shows such a long series of forms of *C. hirsuta* that the three varieties—(α) var. *typica*; (β) var. *sylvatica*; (γ) var. *oxycarpa* distinguished by Hooker fil.—seem no more than fairly constant forms of that species. I also regard *C. Inayatii* O. E. Schulz and *C. loxostemonoides* O. E. Schulz as of the same category; they have the same range as *C. hirsuta*, and the var. *luxurians* O. E. Schulz of the latter is identical with Hooker's var. *sylvatica* of *C. hirsuta*.

8. **Cardamine impatiens** Linn.

Annual or perennial, erect, glabrous, branched, 10–60 cm. tall herb. Leaves very variable, often of two distinct types, the lower and the upper differing in shape and size, intermediate forms are also observed between these two tiers of leaves; shortly petioled, auricled at the base, many-jugate, pinnate with apical leaflets larger, 5–17 or more leaflets in each, petioled, petiole up to 2·5 cm. long, auricles sagittate, embracing sometimes nearly half of the stem up to 8 mm. long and 3 mm. broad, sparsely covered with white hairs or fringed with white bristles; leaflets of the basal leaves more or less orbicular, sometimes nearly entire, slightly wavy or minutely or deeply 2–5-lobed, 4–20 mm. long, nearly as broad, petioluled, petiolule up to 10 mm. long; leaflets of the upper leaves narrower, elongate, very variable in size, elliptic, obovate or obliquely cuneate, lanceolate or linear-lanceolate, entire or sometimes irregularly lobed or incised, rounded, obtuse, or acute at the apices, attenuated towards the base, 5·5 mm. long, 1·5 mm. broad, smooth on both the surfaces, shortly petioluled; petiolule up to 10 mm. long. Inflorescence erect, racemose or somewhat subcorymbose towards the apex. Flowers 3–4 mm. across, white, pedicelled, pedicels 4–7 mm. long; sepals oblong, sometimes pale purple outside towards the tip, 1·5–3 mm. long, 0·5–0·8 mm. broad; petals white, oblanceolate or oblong linear, erect, rounded at the tips, up to 5 mm. long, 1 mm. broad; stamens 6, 4 inner longer, nearly as long as the petals, 2 outer smaller. Pistil shorter than the 4 inner stamens, style very short, stigma globose. Pods erect, slender, linear, with many seeds, stalked, stalks about 10 mm. long in mature fruits, about 3 cm. long without stalk and 1 mm. broad, glabrous. Seeds reddish brown, oval or ellipsoid, 1 mm. long, 0·5–0·8 mm. broad.

Habitat: Common in the Western and Eastern Himalayas from Afghanistan, Kashmir, Punjab, Nepal to Sikkim, from 1025 m. to 3100 m.

9. **Cardamine pratensis** Linn.

Annual or perennial, erect, glabrous, 30–60 cm. tall herb, with rootstock often bearing small, globose, rather fleshy tubers. Leaves both basal and upper ones petiolate, uniformly pinnate, petiole long, more slender, upper ones stouter and patent; leaflets of the basal leaves orbicular, terminal larger, ovate or rounded at the base, shortly petioluled, blade 3–12 mm. in diameter; upper leaves variable, petioluled or subsessile, leaflets ovate, oblong-cuneate, lanceolate or sometimes linear, 5–15 mm. long, 1–3 mm. wide. Racemes elongate, lax, subcorymbose. Flowers lilac, pale purple or purplish red, up to 20 mm. across, somewhat pendulous, pedicellate, pedicels up to 15 mm. long; sepals somewhat subulate oblong, 3·5 mm. long, 2 mm. broad, petals long, obovate or narrowly cuneate at the base, up to 20 mm. long and 10 mm. broad at the tips, pale violet or reddish purple; stamens 6, 4 inner longer, 5–10 mm. long, 2 outer shorter, 3·5 mm. long. Pistil cylindrical, style robust, about 1 mm. long, stigma globose. Pods erect, stouter, somewhat compressed, 15–35 mm. long, 2 mm. broad: seeds oblong oval, 1·5 mm. long, 1 mm. broad, brown.

Habitat: Chiefly confined to the Western Himalaya, abundant in West Tibet, ascending up to 2700 m.

This species of *Cardamine* is frequently used as a member of the ornamental herbaceous border. It exhibits vivipary and is often propagated by means of layering from leaf-axils. The double-flowered form is a useful addition to the garden. Abnormal flowers with leaf-like staminodes have also been found.

10. **Cardamine Griffithii** Hook. f. et Thoms.

Annual or perennial, erect, smooth herb with somewhat creeping rootstock. Stem more or less angled or grooved, hardly sparsely branched above, 30–60 cm. tall. Leaves 3–6 pairs, imparipinnate, subsessile; basal leaves usually absent; leaflets up to 13 in number, sessile or subsessile, lowest pair arising at the base of the petiole, orbicular, ovate or subcordate, oblong or rounded, entire or sinuate, or irregularly trilobate, 4–12 mm. long, 2–10 mm. broad. Racemes somewhat crowded at the apices. Flowers lilac or purple, about 7 mm. across; sepals oblong, about $\frac{1}{3}$–$\frac{1}{2}$ the length of the petals, 2–3 mm. long, 1–2 mm. broad; petals oblong, purple, oblong-obovate, narrowly cuneate, somewhat spathulate, rounded at the apices, 4–10 mm. long, 3–5 mm. broad; stamens 6, 4 inner larger, 5–7 mm. long, 2 outer smaller. Pistil narrowly cylindrical, slightly shorter than the stamens, style slender, about 1 mm. long, stigma rotund. Pods slender, somewhat furcate, sometimes pendulous, 10–15 mm. long.

Habitat: In moist shady places of the higher ranges of the temperate Himalayas extending from Nepal to the Burmese frontier, ascending from 3000 m. to 4200 m.

11. **Cardamine elegantula** Hook. f. et Thoms.

Annual, slender, small, 5–10 cm. tall, branched herb. Leaves glabrous, pinnate; leaflets 3–7 pairs, rather remotely situated, more or less opposite, divaricate, ovate, oblong, rounded, linear oblong or lanceolate, sublobed, angled, entire, lower down distinctly petiolulate, up to 8 mm. long, upper subsessile. Raceme elongate, few-flowered. Flowers white or rose-coloured, 5–7 mm. across, sepals glabrous, somewhat narrowly ovate, about 1·5–2 mm. long; petals white or rose-coloured, clawed, obovate or obovate-cuneate or more or less spathulate; stamens 6, interior 3 mm. long, the outer 2 mm. long. Pistil cylindric, narrow, style short, 0·5 mm. long, subattenuate, stigma globose. Pods slender, narrow linear, horizontal or recurved, more or less pendulous, 10-20 mm. long. Seeds oblong, minute, 0·7–0·8 mm. long, 0·4 mm. broad, and 0·2 mm. thick.

Habitat: In moist temperate zone in the East Himalayas from Bhutan to farther east at an elevation of 2200 m. Chuka, Bhutan; Khasya, Bhutan, William Griffith.

12. **Cardamine macrophylla** Willd.

Perennial, glabrous or slightly pubescent, stout, erect herb with creeping rootstock. Stem simple or branched above, 30–100 cm. tall, somewhat striated. Leaves all pinnate, petiolate; leaflets 12–80 mm. long, 5–40 mm. broad, subsessile, ovate, obovate-cuneate lanceolate or narrowly lanceolate, crenate-serrate, pinnatifid or sometimes coarsely irregularly lobed or cut, obtuse, acute or acuminate. Racemes long, subcorymbose. Flowers pedicellate, rose-coloured or purple, many somewhat crowded at the end of racemes, about 8-15 mm. across; sepals oblong, 3–5 mm. long, 1–2 mm. broad, petals 10–15 mm. long, 3 5 mm. broad, narrowly cuneate obovate, rose-coloured or purple, broadly rounded, rarely emarginate; stamens 6, 4 inner 6 mm. long, 2 outer 4 mm. long. Pistil cylindric, about 5 mm. long, style 1-2 mm. long, stigma large, globose. Pods elongate erect or erecto-patent, smooth, slightly attenuated at both ends, about 25–50 mm. long, 1·5–2 mm. broad, pedicellate, pedicel up to 20 mm. long. Seeds oblong, 1·5–2 mm. long, 1–1·2 mm. broad, 0·5 mm. thick, brown.

Habitat: Throughout the temperate East and West Himalayas ascending from 2500 m. to 5300 m.

Four varieties of *C. macrophylla* are distinguished by Hooker f. and Thomson in the Journ. Linn. Soc. London (Bot.), v, 145, 1861: (i) var. *dentariifolia* (*C. dentariifolia* Royle apud Hook. f. et Thoms.), leaflets lanceolate or ovate lanceolate, cuneate or serrate, obtuse, flowers large, white or violet, pods $\frac{1}{2}$–1$\frac{1}{4}$ in.; (ii) var. *foliosa*, leaflets narrow lanceolate acuminate, subpinnatifid; flowers white, pods 1–1$\frac{1}{2}$ in., pale coloured; (iii) var. *lobata*, leaflets ovate lanceolate, irregularly and coarsely lobed or cut, lobes obtuse; flowers and pods as in var. *foliosa* but the plant larger; (iv) var. *sikkimensis*, tall and coarse, leaflets ovate-lanceolate, obtusely serrate; flowers large, deep violet, pods large and broad, $\frac{3}{4}$ in. long, pale brown. The variety *dentariifolia* has been sunk by O. E. Schulz in the subspecies *polyphylla* (Don) O. E. Schulz (*Cardamine polyphylla* Don, Prod. Flor. Nepal, p. 201, 1825). O. E. Schulz has added another variety—(v) var. *venusta* O. E. Schulz—cauline leaves 4–6 jugate, 8·5–11·5 cm. long, leaflets crenate serrate or deeply incised serrate, distinctly petiolulate, 15–22 mm. long, 6–12 mm. broad; flowers large, 12–15 mm. long.

Detailed examination of all these varieties shows that there are among the specimens many intermediate forms which come very close to one or the other. They seem to be much influenced by ecological variations at different elevations. Taking into consideration all the available material at the Herbariums, Kew, Edinburgh, British Museum (Natural History), London, Calcutta, and Oxford, it leads me to differentiate two distinct sets of Indian *C. macrophylla*. These I consider can better be distinguished as two different varieties of the species proper. The two varieties are characterised as follows:—

I. Leaflets ovate-lanceolate, lanceolate, narrow lanceolate, crenate or serrate, subpinnatifid or coarsely lobed, obtuse, acute or acuminate: flowers white or violet; pods 1–4 cm. long—var. *foliosa*.

II. Leaflets ovate-lanceolate, obtusely serrate; flowers large, deep violet; pods larger and broader, 5 cm. long—var. *sikkimensis*.

Hooker f. and Thomson report that the var. *foliosa* is confined to the Western Himalaya, from West Kumaon to Kashmir. But subsequent collections show that although the variety is abundant in the Western Himalaya, it is not less common in the Eastern Himalaya. Var. *sikkimensis* is supposed to be confined to the Eastern Himalaya, but specimens of this variety from the Western Himalaya prove that the variety *sikkimensis* is also common in the Western Himalaya.

13. **Cardamine ovata** Bentham.

Annual or perennial, erect herb, 10–75 cm. tall; sparsely branched towards the upper part of the stem, regularly 4–8-foliate. Leaves 6–17 cm. long, stalked, petiole 1–10 cm. long, 2-jugate, imparipinnate; leaflets ovate, 1–4·5 cm. long, 5–20 mm. broad, sessile or subsessile, cuneate or oblong-ovate, lanceolate, widely crenate, serrate, rarely subentire, obtusely rounded or acute, sparsely pilose on both the surfaces, particularly younger upper leaflets. Raceme about 13 cm. long, flowering from nearly the middle of the peduncle, sub-lax, elongating in fruit with trifoliate smaller bracteate leaves, rarely naked; flowers pedicellate, pedicels up to about 12 mm. long. Flowers up to about 10 mm. across, pale purple or pink;

sepals 4–5 mm. long, up to about 1–2 mm. broad, pale green, oblong, obtuse or acute at the apices; petals 8–11 mm. long, 4–5 mm. broad, narrowed towards the base, somewhat spathulate, or generally obovate-cuneate, widely rounded at the apices; stamens 6, 4 inner longer, 5–7 mm. long, 2 outer shorter, about 3–5 mm. long. Pistil cylindric, 5–7 mm. long, ovary 3 mm. long, style 2 mm. long, stigma globose. Pods pedicellate, subhorizontal or more or less recurved, long, narrow, 1–8 mm. broad; pedicel 4–5 cm. long. Seeds oblong, 2 mm. long, 1·1 mm. broad.

Habitat: In moist places in woods in the Western Himalaya (in Gulmerg, Kashmir, collected by Mrs. Prescott Decie in 1915) at an elevation of 2125 m.

This species is a new record from India.

THE GENUS PRIMULA: SECTION SIKKIMENSIS Balf. fil.

By W. WRIGHT SMITH and H. R. FLETCHER.

(Read 17th June 1943.)

Primula sikkimensis and its allies form a very distinct section and this was first recognised by Balfour (1) when dealing with the Chinese species of Primula in 1913 at the Third Primula Conference. He chose the dominant species, *P. sikkimensis*, as the type of his section, included certain Chinese species within the section, but did not clearly mark it off by any diagnostic characters. Of the plants cited by Balfour the following were excluded from the section by Smith and Forrest (2) in 1928 at the Fourth Primula Conference: *P. orbicularis*, *P. reflexa*, and *P. tsetzouensis*. In their paper (*l.c.*, 4, 38) the section is briefly differentiated by the character of the corolla which is bell-shaped with erect non-patent lobes. This criterion is shown by three other sections (*l.c.*, 4) which have no kinship whatever with Sikkimensis and are readily separated from it. A similar corolla-shape occurs otherwise only very rarely in the genus, but it is consistent throughout Sikkimensis. Other diagnostic marks but of less significance are: the lack of fleshy scales or of a massive bud in the resting stage, the average consistency of the serrate or crenate leaves which are efarinose but may show farinipotent glands, the usually single umbel of few or many pendent flowers which are usually more or less farinose, the cylindrical capsule, and the irregularly rectangular to ovoid seeds which are sometimes almost smooth but may be vesicular-surfaced.

The history of the section is brief. The only two species known to Hooker (3) were *P. reticulata* and *P. sikkimensis*, and their relationship is clearly indicated by him. In 1905 in his Monograph, Pax (4) placed *P. reticulata* in his section Cordifolia, *P. sikkimensis* and *P. secundiflora* in Nivales, and *P. vittata* doubtfully in Callianthae. Reference has already been made to the outlining of the section by Balfour (1) in 1913. The list of species given in 1928 by Smith and Forrest (2) contains no alien element, but in this revision certain changes have been made in the status of the components. Three species described since 1928 are here included.

The general morphology of Sikkimensis does not indicate any near affinity to any other section and it appears isolated to a considerable degree. No problem of any intermediates presents itself. *P. secundiflora* is somewhat aberrant but is still well within the section. The cytological data have been fully elucidated by Bruun (5). He states (*l.c.*, 97) that the nuclei of Sikkimensis differ in their small narrow chromosomes from all other Primula nuclei and that the cytology is unable to give more than a hint as to where to look for the section that is most nearly related. There may be a link, even if remote, with Candelabra and Nivales. The species of Sikkimensis show a marked uniformity in their karyotypes with the exception that *P. secundiflora* exhibits a distinct divergence, but the degree of difference is far from warranting exclusion from the section.

The distribution of the section is wholly Asiatic. Its area includes the Himalaya of Nepal, Sikkim and Bhutan, southern and eastern Tibet, the provinces of Yunnan and Szechwan in western China, and a corner of N.W. Burma. The only widespread species is *P. sikkimensis* which occurs throughout the range of the section. The species found in the Himalaya and in China show little or no tendency to variation except in the case of *P. sikkimensis.* But in Tibet explorers have remarked several instances of intermediates suggesting interspecific hybridisation. Consequently, the closely related species found from Lhasa eastwards and southwards in the basin of the Tsangpo—*P. alpicola*, *P. Florindae*, *P. ioessa*, *P. sikkimensis* vars., and *P. Waltoni*—while readily recognisable in typical condition, may show variation and mixing of colours which are at least in part to be attributed to hybridity. But *P. alpicola*, on the other hand, may express itself in three distinct colours without any clear evidence that there is an alien element. The exact relationships of these Tibetan species require further observations in the field. See also comments under the descriptions of the above five species.

The discrimination of the species of this section is far from easy, and we are not assured that the treatment given in this review is always consistent. Of the criteria used in the key the shape of the lamina is in great measure quite reliable. The colour of the corolla is less diagnostic as some species tend to be polychrome. This is very evident in *P. alpicola* where at least three colours are shown by plants in close proximity. The rich hues of *P. Waltoni* and of *P. ioessa* sometimes give place to lighter tints and even to white. *P. sikkimensis* is usually uniform in its shades of yellow, but var. *Hopeana* shows a white corolla and thus approaches albino forms of the two species just mentioned. Where divergences in the colour of the corolla are linked with geographical separation (as in the species of the Himalaya and of China) the criterion of colour is valid and is supported by other data.

The section is one which is amenable in culture and the great majority of the species have been in cultivation at one time or another. Five of them, robust as well as attractive, can be regarded as established in gardens: *P. alpicola*, *P. Florindae*. *P. secundiflora*, *P. sikkimensis*, and *P. Waltoni*. These all come from moist alpine areas and in this country quickly resent conditions of drought during the growing season. As a rule seed production is fairly satisfactory. Unless grown in large and isolated groups they are prone to hybridise, as may be anticipated from their similarity in general morphology and in their cytology.

Hybrids occurring between species of different sections are of very rare occurrence in the genus, and such as have been recorded require confirmation in most cases by means of controlled experiments. Dr. Handel-Mazzetti (6), an acute botanist and careful observer, has described *P. dschungdienensis* as a cross between *P. Poissonii* and *P. secundiflora*. This was found by him in 1914 on the Chungtien plateau at 3350 m., in company with its parents. He gives a detailed analysis of the hybrid which tends to favour *P. secundiflora*. The chromosome number of each parent is 22.

REFERENCES.

(1) Balfour in Journ. Roy. Hort. Soc. London, xxxix, 159 (1913).
(2) Smith and Forrest, *ibid.*, liv, 42 (1929), and in Notes Roy. Bot. Gard. Edin., xvi, 38 (1928).
(3) Hooker in Fl. Brit. Ind., iii, 483 (1882).
(4) Pax in Engl. Pflanzenr. Primulaceae, 100, 118, 120 (1905).
(5) Bruun, Cytological Studies in Primula, 92, 127 (1932).
(6) Handel-Mazzetti in Anz. Akad. Wiss. Wien, lvii, 87 (1920).

KEY TO THE SPECIES.

A. Flowers yellow or white:
B. Flowers yellow:
C. Lamina longer than broad, of elliptic to oblong type:
D. Lamina attenuate at base; reticulation open and not prominent below:
E. Leaves membranous; reticulation not obscure below . *sikkimensis*
EE. Leaves coriaceous; reticulation obscure below . *chumbiensis*
DD. Lamina cordate, truncate or rounded at base; reticulation close and very prominent below:
E. Lamina ± rounded at base; corolla-lobes emarginate and ± patent; stamens in pin-eyed flowers near base of corolla-tube; long style barely as long as corolla-tube *alpicola* var. *luna*
EE. Lamina ± cordate at base; corolla-lobes ± entire, suberect; stamens in pin-eyed flowers in middle of corolla-tube; long style slightly exserted . . . . . . *reticulata*

CC. Lamina almost as broad as long, of broadly ovate to suborbicular type:
  D. Very robust; lamina up to 20 cm. long and 15 cm. broad; scape up to 120 cm. tall and carrying as many as 80 flowers; bracts 10–30 mm. long; capsule nearly twice the length of the calyx. *Florindae*
  DD. Slender; lamina up to 7 cm. long and 5 cm. broad; scape up to 40 cm. long and carrying at most 8 flowers; bracts at most 12 mm. long; capsule a little longer than calyx . . *firmipes*
BB. Flowers white:
  C. Lamina attenuate at base; reticulation open and not prominent below:
    D. Leaves ± incised; calyx black; corolla as broad as long. *ioessa* var. *subpinnatifida*
    DD. Leaves serrate; calyx green; corolla longer than broad. *sikkimensis* var. *Hopeana*
  CC. Lamina cordate to truncate to rounded at base; reticulation close and very prominent below:
    D. Lamina ± rounded at base; corolla-lobes emarginate and ± patent; stamens in pin-eyed flowers near base of corolla-tube; long style barely as long as corolla-tube *alpicola* var. *alba*
    DD. Lamina ± cordate at base; corolla lobes ± entire, suberect; stamens in pin-eyed flowers in middle of corolla-tube; long style slightly exserted . . . . *reticulata*
AA. Flowers red or purple or various shades of mauve:
  B. Lamina cordate to truncate to rounded at base:
    C. Lamina almost as broad as long; completely efarinose . *erythra*
    CC. Lamina longer than broad; inflorescence farinose:
      D. Corolla-lobes patent obcordate, emarginate; scape often with more than 1 umbel; stamens in pin-eyed flowers near base of corolla-tube; long style barely as long as corolla-tube. S.E. Tibet . . . . *alpicola* var. *violacea*
      DD. Corolla-lobes ± erect, ± elliptic, subentire; scape with only 1 umbel; stamens in pin-eyed flowers in middle of corolla-tube; long style slightly exserted. Nepal . . . . *didyma*
  BB. Leaves attenuate at base:
    C. Petiole at flowering time markedly developed; calyx without vittae of farina:
      D. Corolla as broad as long, without a red eye; leaves ± incised *ioessa*
      DD. Corolla longer than broad, with a red eye; leaves serrate . *Waltoni*
    CC. Petiole at flowering time almost obsolete; calyx with vittae of farina. . . . . *secundiflora*

P. alpicola Stapf in Bot. Mag., t. 9276 (1932), including subsp. *luna* Stapf and subsp. *violacea* Stapf; Quart. Bull. Alp. Gard. Soc., iv, 343, fig. p. 345 (1936). *P. microdonta* var. *alpicola* W. W. Sm. in Notes Roy. Bot. Gard. Edin., xv, 85 (1926); W. W. Sm. and Forrest, *ibid.*, xvi, 39 (1928), and in Journ. Roy. Hort. Soc., liv, 42 (1929); Ward, Riddle Tsangpo Gorges, 75, 77, 130, 156, 167, 179 (1926), and in Gard. Chron., lxxxii, 172, fig. 77 (1927), and *ibid.*, lxxxviii, 32 (1930); Besant in *ibid.*, xc, 70, fig. 33 (1931); Bruun, Cytological Studies in Primula, 94, 127 (1932), *P. sikkimensis microdonta* Stapf in Bot. Mag., t. 9210 (1930), *pro parte* nec fig. *Primula sp.* Ward in The Garden, lxxxix, 447 (1925), and in Gard. Chron., lxxvii, 318 (1925), and *ibid.*, lxxviii, 12 (1925).

The first account of the discovery in 1924 of this species as well as of *P. Florindae* is given by Ward (The Garden, lxxxix, 447; Gard. Chron., lxxvii, 318). He refers to it there as the "Moonlight" Primula and the herbarium numbers concerned are *Ward* 5746, 5818, 6095, 6117. From his field observations he points out quite clearly that the plant shows remarkable variation in colour—yellow, white, and violet—without deviation in the general morphology and without geographical barriers. He notes also its tendency to produce up to four whorls of flowers, resembling in that respect the section Candelabra. From the second reference may be quoted: "There is no confusing the two species in flower, though immature plants are apt to resemble one another; but . . . it may be stated that the corolla of the 'giant sulphur' is narrow bell-shaped, with pointed lobes; that of 'moonface' . . . is saucer-shaped, with rounded, cleft lobes."

In the publication in 1926 by Smith and Ward (*l.c.*, 85) dealing with the Primulas of Ward's 1924 expedition in Tibet, the above-quoted material was considered to represent a variety of a Szechwan and Yunnan plant, described by Petitmengin as *P. microdonta*. (This latter is now known to be a long-petioled form of *P. sikkimensis* itself.) The "Moonlight" Primula thus was called at first *P. microdonta alpicola*. Seed collected by Ward produced vigorous flowering plants in 1926–7 which permitted a better analysis. The first revision was made in 1930 by Stapf (under Bot. Mag., 9210). The Wardian plants, along with *P. Waltoni*, are there treated as subordinate to *P. sikkimensis* and the "Moonlight" Primula becomes *P. sikkimensis microdonta*. The figure itself does not represent it but is quoted later by Stapf (sub Bot. Mag., 9276) as his *P. vinosa*. Further acquaintance with the living material induced Stapf in 1932 to alter his opinion and under Bot. Mag., 9276, he gives his conclusions. He divorces the Tsangpo plant from both *P. sikkimensis* and *P. microdonta* and gives it a specific status as *P. alpicola*, with which view we concur. He divides the species into two subspecies—*P. alpicola luna* with yellow flowers and *P. alpicola violacea* with violet purple or white. The very fine figure shows both.

The plants raised from the first sending of seed gave flowers of the three colours mentioned by Ward. Their immediate successors did for a time breed true as to colour. In culture, however, there is often no barrier to hybridisation and in recent years there is ample evidence that blends are present. Apart from colour there are, however, no morphological differences. For horticultural purposes the species can be regarded as divisible into *P. alpicola* *luna*, *P. alpicola violacea*, and *P. alpicola alba*—three varieties. According to Ward (Gard. Chron., lxxxviii, 32) "the main colours group themselves clearly into four camps: (1) white; (2) yellow (neither of these show any variation); (3) purples; (4) violets. The whites and yellows usually come true from seed: the purples and violets are more difficult to segregate. There are various tones and semitones and all seem to cross and recross in varying degrees, giving a lovely scale of colour."

The species is restricted in its distribution to the basin of the Tsangpo in S.E. Tibet. It is found in shady bogs and moist alpine pastures at 3700–4600 m. One near ally is *P. Florindae*, from which it differs in its matt foliage and corolla-shape (see under that species). From *P. sikkimensis* the shape and quality of its leaves are an easy distinction. An even closer ally may prove to be *P. reticulata*, for slender states of *P. alpicola* show a distinct resemblance. The cytology of the species (Bruun, *l.c.*) affords no additional criteria. Hybrids between it and *P. Florindae* appear to occur in nature as well as in culture (see under *P. Florindae*).

A perennial plant, efarinose except for the inflorescence, with a short but stout rootstock. Leaves including the petiole 10–30 cm. long, 2–8 cm. broad; lamina elliptic to oblong-elliptic, rounded at apex, truncate or rounded or slightly cordate or shortly cuneate at base, denticulate or crenulate, with matt non-shining surface, glabrous and efarinose but with many farinipotent glands below giving a scabrid appearance; midrib conspicuous above, broad below; lateral nerves 10–20 pairs, sometimes leaving the midrib almost at a right angle, prominent and subparallel, forming with the nervules a characteristic fine reticulation; petiole 1–2 times the lamina, membranously winged, sheathing at the base. Scape 15–90 cm. tall, slightly farinose at apex, carrying usually a single, or two superposed, or (ex Ward) sometimes four umbels of numerous flowers; bracts 1–2 cm. long, 2–8 mm. broad, narrowly lanceolate to oblong or even ovate, green to deep reddish-brown, usually with farina, sometimes pouched at base; pedicels 1–8 cm. long, farinose. Calyx 8–10 mm. long, obovoid to campanulate or tubular-campanulate, farinose without, densely within, often covered with purplish striae particularly in the region of the five prominent nerves, cut for a third to a half into triangular to lanceolate acute recurved teeth. Corolla white, yellow, purple or violet, 1·5 to nearly 2·5 cm. long; tube 1–2 times the calyx, cylindrical, suddenly ampliate above insertion of stamens and gradually passing into limb; limb up to 3 cm. diameter, with broadly obcordate to subrotundate emarginate lobes, covered with yellow farina within especially at base. Stamens, with anthers nearly 2 mm. long, inserted towards apex of corolla-tube in thrum-eyed flowers, near base in pin-eyed. Long style barely as long as corolla-tube; short style 2 mm. long. Capsule cylindrical, 1-1½ times the calyx, dehiscing by longitudinal valves. Seeds about 1·5 mm. long, ovoid, brown, smooth but under strong lens with reticulate surfacing.

The type specimen of the plant as *P. microdonta alpicola* is *Ward* 5746 in the Kew Herbarium. Its specific description as *P. alpicola* is based on living material grown at Kew and preserved in the same Herbarium. The species is represented thus in Edinburgh:—

P. alpicola var. **luna** (Stapf, *l.c.*) comb. nov.

S.E. TIBET: Temo La (*Ward*, 5746—*co-type* of var.); Doshong La (*W.* 5818—*pro parte*); Nambu La (*W.* 6095); Tse Gar (*W.* 11929); Druk-la Gompa (*W.* 6117); Tsari, Bimbi La (*Ludlow and Sherriff*, 2120); Tsari Chu, Migyitun (*L. and S.*, 1689); Langong Chu Valley (*L., S. and Taylor*, 5522).

BHUTAN: Rinchen Chu (*Ludlow and Sherriff*, 3353, 3370, 3449); Tang Chu (*L. and S.*, 3379).

P. alpicola Stapf var. **violacea** (Stapf) W. W. Sm. in Notes Roy. Bot. Gard. Edin., xix, 214 (1937).

S.E. TIBET: Nyima La (*Ward*, 5818—*pro parte*—*co-type* of var.); Tsari Valley (*W.* 11867); Tsari Chu, Migyitun (*Ludlow and Sherriff*, 1685); Tsari Sama, Langong (*L., S. and Taylor*, 5588); Tum La, Nagü (*L., S. and T.*, 5770); sine loc. (*L., S. and T.*, 4665, 5214).

P. alpicola Stapf var. **alba** W. W. Sm.*

S.E. TIBET: Kyindong Dzong (*Ludlow and Sherriff*, 1833—*type* of var.); Tsari, Migyitun (*L. and S.*, 2106).

P. chumbiensis W. W. Sm. in Trans. Bot. Soc. Edin., xxvi, 118 (1912); Craib in Journ. Roy. Hort. Soc., xxxix, 189 (1913); W. W. Sm. and Forrest, *ibid.*, liv, 42 (1929), and in Notes Roy. Bot. Gard. Edin., xvi, 39 (1928); Cooper, *ibid.*, xviii, 102 (1933).

P. chumbiensis is known only from the Tibetan valley of Chumbi which lies just beyond the eastern boundary of Sikkim. The original description is based on specimens found at 5000-5300 m. in 1912 by Rohmoo, one of the Lepcha collectors of the Lloyd Botanic Garden, Darjeeling. But in the Calcutta Herbarium there is material obtained in 1882 by Dungboo, Sir George King's collector, from near the snow on Chomolari, a mountain on the borders of Chumbi. King has a note (*in scheda*) pointing out that the specimens are much smaller than typical *P. sikkimensis* and that the leaves are more abruptly narrowed at the base. In another hand is a further note ascribing the plant to *P. sikkimensis*, but stating also that H. J. Elwes who had it in cultivation considered it different. The first diagnosis associates it more nearly with *P. reticulata* on account of the shape of the lamina. From that species it differs in the much smaller and proportionately less elongate coriaceous leaves and subulate bracts. Neither does it agree with the extreme alpine expressions of *P. sikkimensis* which fall under var. *pudibunda*. *P. reticulata* and *P. sikkimensis* are quite distinct from one another, and *P. chumbiensis* appears to occupy an intermediate position. The evidence does not suffice to attach it in a subordinate status to either and there is no suggestion of hybridity. Its behaviour in cultivation would no doubt help to solve the problem, but there is no record of it in gardens apart from the brief reference of over sixty years ago.

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* Floribus albis tantum divergit.

A glabrous plant, 10–30 cm. tall, with a short comparatively stout rhizome. Leaves including the petiole 2–12 cm. long; lamina 1–4 cm. long, 1–2 cm. broad, ovate-oblong or oblong to elliptic, rounded at the apex, rounded or cuneate or cordulate at the base, crenate-serrate, coriaceous, glabrous and efarinose but minutely scabrid on the lower surface, rugose and somewhat bullate above where the nerves are impressed, midrib broad below with lateral nerves prominent and nervules more or less obscure; petiole quite discrete, one to three times the lamina, slightly membranously winged. Scape 10–25 cm. tall, faintly farinose towards the apex, carrying an umbel of 2–7 flowers, occasionally 1-flowered; bracts linear-lanceolate to subulate, 3–12 mm. long, faintly farinose, sprinkled with reddish striae; pedicels 1–4 cm. long at flowering time, up to 8 cm. long at fruiting time, slightly farinose. Calyx 5–10 mm. long, tubular to tubular-campanulate, conspicuously 5-nerved, with a little farina and numerous reddish striae without, more copiously farinose within, cut to about the middle into triangular-lanceolate erect or recurved lobes. Corolla 1·5–2·5 cm. long, yellow, exannulate, heteromorphic; tube as long as or twice as long as calyx, narrowly cylindrical up to insertion of stamens; limb 1–1·5 cm. across, farinose within, with suberect ovate to elliptic entire or emarginate lobes. Stamens, with anthers 1·5 mm. long, inserted towards apex of cylindrical part of corolla-tube in thrum-eyed flowers and towards base of tube in pin-eyed. Long style as long as or half as long again as calyx; short style 1–2 mm. long. Capsule more or less oblong, as long as or shorter than calyx. Seeds. . . .

It is thus represented at Edinburgh:—

S. TIBET: Chumbi Valley, Eastern Himalaya, at Chumegati (*Rhomoo*. 317—*type*); at Kalaeree (*R*. 407); on Chomolari (*Dungboo* in 1882); Yele La near Chomolari (*Cooper*, 1832).

P. didyma W. W. Sm. in Notes Roy. Bot. Gard. Edin., xvi, 228 (1931); Bruun, Cytological Studies in Primula, 94, 127 (1932). ? *P. speciosa* Don, Prodr. Fl. Nepal., 78 (1825).

This plant is known only from the mountains of Nepal where it was first collected by Major Lal Dhwoj in 1930. It is recorded from elevations of 3500–4600 m. It is closely akin to *P. reticulata* from which it differs in the colour of the corolla. Its other characters are so much in unison with those of *P. reticulata* that it could be assessed as subordinate to that species. *P. didyma* is very possibly the same as the Wallichian plant described by Don (*l.c.*) as *P. speciosa*, with purple flowers. Don dealt with only a moiety of the Wallichian Herbarium for his Flora Nepalensis and his specimens are no longer extant. In any case his specific name is preoccupied. Seed from Nepal raised at Edinburgh in 1931 produced a group of flowering plants which persisted up to 1936 but left no successors.

A comparatively stout plant with a short rhizome. Leaves including the petiole 10–25 cm. long; lamina 5–12 cm. long, 2·5–4 cm. broad, ovate to oblong, rounded at the apex, cordate or subcordate or almost round and then suddenly decurrent at the base, crenate-dentate to crenate-denticulate at the margin, glabrous but with a thin covering of potentially farinose glands below; midrib broad with lateral veins and nervules forming a prominent reticulation; petiole 5–12 cm. long, slightly winged, sheathing at the base. Scape 25–30 cm. long, rather slender at flowering time, much stouter in fruit, farinose at the apex, carrying an umbel of about 5–10 pendent flowers; bracts 1–2·5 cm. long, lanceolate to ovate-lanceolate, acuminate and sometimes slightly toothed at the apex, green but with numerous minute red striae and occasionally a little farina; pedicels 1–7 cm. long, slender, slightly farinose. Calyx 8–12 mm. long, tubular to tubular-campanulate, usually sparingly farinose within and without, occasionally more copiously, covered with reddish striae, prominently 5-ribbed, cut to a third into triangular to lanceolate acute and slightly recurved lobes.

Corolla mauve-blue, exannulate, heteromorphic; tube usually about half as long again as calyx, sometimes only as long, cylindrical, ampliate above insertion of stamens; limb 1–1·5 cm. across, copiously yellow-farinose around the base within; lobes oblong to obovate, faintly emarginate or undulate. Stamens, with anthers 2 mm. long, inserted in middle of corolla-tube in pin-eyed flowers. Long style as long as tube or a little exserted. Capsule oblong, as long as calyx or slightly longer, dehiscing by longitudinal valves.

It is thus represented at Edinburgh:—

NEPAL: Maney Dara (*Lal Dhwoj*, 453—*type*); Ratomatey (*Sharma*, 444).

P. erythra Fletcher. Nom. nov. *P. rubra* Ward in Annals of Botany, xliv, 124 (1930), nec Gmelin; Ward in Gard. Chron., lxxxviii, 32 (1930).

This species is known only from the Delei Valley in the Assam Himalaya where it was found by Ward in 1928 at 3600 m. He records it (*in scheda*) as growing in mountain gullies and by trickling streams, but more often in the open on very wet loam. As the specific title given to it by Ward is unfortunately preoccupied, a new name is necessary. The nearest allies are undoubtedly *P. firmipes* and *P. didyma*. From the former it differs in the quality and fine scabridity of its leaves, in the lack of farina on the inflorescence and in the colour of the corolla; from the Nepal plant it deviates markedly in leaf-shape, as also in absence of farina. Seeds were sent home by Ward, but there is apparently no evidence that the plant reached flowering stage in culture.

An efarinose perennial with a short rhizome. Leaves including the petiole 7–28 cm. long; lamina 2–10 cm. long, 2–7 cm. broad, very broadly ovate, rounded at the apex, deeply cordate at the base, conspicuously and irregularly crenate-dentate, minutely scabrid below; midrib broad and forming with the 5 to 10 pairs of lateral nerves and the nervules a close and strong reticulation on the lower surface; petiole 6–18 cm. long, sheathing at the base and very slightly winged. Scape 35–40 cm. tall, slender, minutely scabrid especially towards the apex, carrying an umbel of 6–15 semi-erect flowers; bracts 8–12 mm. long, linear to linear-lanceolate, finely scabrid and covered with dull reddish striae; pedicels 1–1·5 cm. long, slender, tawny-scabrid. Calyx 6–7 mm. long, tubular-campanulate, slightly scabrid, strongly veined but scarcely angled, cut to a third into lanceolate acute ciliolate lobes. Corolla maroon-red, exannulate, heteromorphic; tube 8–10 mm. long, yellow inside, narrowly cylindrical, slightly ampliate above the insertion of the stamens; limb 10–18 mm. in diameter; lobes broadly ovate or almost round, faintly emarginate or crenulate. Stamens, with anthers 2 mm. long, inserted near the apex of the corolla-tube in thrum-eyed flowers. Short style almost as long as calyx. Capsule and seeds. . . .

The type specimen is in the Kew Herbarium and the representation at Edinburgh is:—

ASSAM HIMALAYA: Mishmi Hills, Delei Valley (*Ward*, 8380—*co-type*).

P. firmipes Balf. f. et Forrest in Notes Roy. Bot. Gard. Edin., xiii, 10 (1920); Forrest in Journ. Roy. Hort. Soc., xlix, 34 (1924); Ward in Gard. Chron., lxxxii, 172 (1927); W. W. Sm. and Forrest in Notes Roy. Bot. Gard. Edin., xvi, 39 (1928), and in Journ. Roy. Hort. Soc., liv, 42 (1929); Bruun, Cytological Studies in Primula, 94. 127 (1932). *P. flexilipes* Balf. f. et Forrest in Notes Roy. Bot. Gard. Edin., xiii, 10 (1920); Forrest in Journ. Roy. Hort. Soc., xlix, 34 (1924); Journ. Roy. Hort. Soc., lii, Proc., p. lvi (1927); Hand.-Mzt., *ibid.*, liv, 61 (1929); Adamson, *ibid.*, 82 (1929); Bruun, Cytological Studies in Primula, 94, 127 (1932); Cooper in New Flora and Silva, v, 185 (1933). *P. firmipes* subsp. *flexilipes* W. W. Sm. et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 39 (1928), and in Journ. Roy. Hort. Soc., liv, 42, fig. 47 (1929). *P. deleiensis* Ward in Annals of Botany, xliv, 124 (1930).

This plant was first collected by Forrest in 1919 in the Tibetan province of Tsarong. It grows in wet alpine meadows, by streams and on the margins of thickets at 3000–4500 m. Like other members of the section it varies much in vigour according to the environment. The material now available affords good evidence that *P. flexilipes* and *P. deleiensis* should be included within *P. firmipes*. The nearest allies appear to be *P. reticulata* and *P. erythra*. The shape and tenuity of the leaves of *P. reticulata* are a ready means of distinction. The lack of farina and the colour of the corolla in *P. erythra* keep it apart from *P. firmipes*. Seeds obtained by Forrest in 1924 produced flowering plants and the species remained in culture (as *P. flexilipes*) until 1940, but is probably now lost.

A graceful and usually slender plant with a short stout rootstock. Leaves including the petiole 3–25 cm. long; lamina 1–7 cm. long, 1–5 cm. broad, ovate or suborbicular or elliptic, rounded at the apex, cordate at the base, deeply crenate-dentate at the margin. glabrous on both surfaces or very finely scabrid below with potentially farinose glands; midrib broad, with 4–8 pairs of distinct lateral nerves; petiole 2–20 cm. long, slightly membranous, winged, sheathing at the base. Scape 10–40 cm. tall, slender or stout, slightly yellowish-farinose at the apex, carrying an umbel of 2–8 nodding flowers; bracts 7–12 mm. long, lanceolate to ovate-lanceolate, acuminate, often minutely denticulate, sometimes covered with minute red striae; pedicels 1–4 cm. long, slender, slightly farinose. Calyx 5–8 mm. long, broadly campanulate, farinose, 5-angled, cut to the middle into lanceolate to triangular-lanceolate acute and usually slightly recurved teeth. Corolla 2–2·5 cm. long, soft primrose-yellow, exannulate, heteromorphic, farinose within and without; cylindrical part of tube about twice as long as calyx, gradually widening upwards into limb; limb 1·5–2 cm. across, copiously farinose at the base within, with suberect obovate emarginate or crenulate lobes. Stamens, with anthers 1·5 mm. long, inserted at apex of cylindrical part of tube in thrum-eyed flowers, about 2 mm. from base of tube in pin-eyed. Long style as long as cylindrical part of tube or a little longer: short style 1 mm. long. Capsule as long as or a little longer than the calyx, dehiscing by longitudinal valves. Seeds about 1·5 mm. long, irregularly ovoid, smooth, showing under the lens minute reticulations.

It is thus represented at Edinburgh:—

S.E. Tibet: Tsarong, Salwin–Kiu-chiang divide (*Forrest*, 18999—*type*, 18874—*type* of *P. flexilipes*, 19884, 20222, 20231, 20233, 20245, 22929); Tsarong, Mt. Kenichunpo, north of Sikitung, Upper Salwin River (*Rock*, 22171, 22547); Tsari Sama, Langong (*Ludlow, Sherriff and Taylor*, 5575).

N.W. Yunnan: Salwin–Kiu-chiang divide (*Forrest*, 21791, 25568); near the Tibetan-Burmese border, between the Salwin and Irrawadi Rivers (*Hand.-Mzt.*, 9205).

N.W. Burma: Valley of the Seinghku (*Ward*, 7227, 7512).

Assam Himalaya: Mishmi Hills, Delei Valley (*Ward*, 8381—photograph of *type* of *P. deleiensis*).

P. Florindae Ward in Notes Roy. Bot. Gard. Edin., xv, 84 (1926); W. W. Sm. and Forrest, *ibid.*, xvi, 39 (1928); Ward in The Garden, lxxxix, 447, with fig. (1925); *ibid.*, xc, 322, fig. p. 313 (1926); Ward in Gard. Chron., lxxvii, 318 (1925), and *ibid.*, lxxviii, 12, figs. 7, 8 (1925); *ibid.*, lxxix, 399, fig. 205 (1926);

Ward, *ibid.*, lxxxii, 172–174, fig. 76 (1927); *ibid.*, lxxxiv, 168, fig. p. 190 (1928); *ibid.*, lxxxvi, 225 (1929); Ward, *ibid.*, lxxxviii, 32 (1930); *ibid.*, xciv, 97 (1933); *ibid.*, civ, 11 (1938); Ward in Journ. Roy. Hort. Soc., lii, 23, 232, Proc., p. lv, figs. 27, 74 (1927); W. W. Sm. and Forrest, *ibid.*, liv, 42, fig. 49 (1929); McLaren, *ibid.*, liv, 64, 67 (1929); Adamson, *ibid.*, liv, 82 (1929); Tincker, *ibid.*, lx, 177 (1935); Bruun, Cytological Studies in Primula, 94, 127 (1932).

This very robust species was one of the discoveries of Captain Kingdon Ward in 1924 in S.E. Tibet. He records it from 4000 m. growing in shady bogs, by running water and even in the streams. Seed was secured in the same year and the resultant plants were in flower in 1926, gaining a First Class Certificate from the Royal Horticultural Society. It surpasses the other members of the section in vigour and is quite amenable in culture, seeding freely. This quite distinct species finds its nearest ally in *P. alpicola* from which it differs in the shining Caltha-like leaves, nearly as broad as long, more deeply and regularly dentate, in the narrower sulphur-yellow corolla and in the copious yellow farina on calyx and corolla. It appears to be abundant in many places in the basin of the Tsangpo and often in company with *P. alpicola*. Tibetan species of this section hybridise in culture and there is clear evidence that they occasionally do so in their native haunts. Their cytology suggests no impediment (Bruun, *l.c.*). Plants otherwise quite similar to *P. Florindae* have been collected with reddish amber flowers and this colour-change may or may not be due to crossing. But other specimens are apparently intermediates between *P. alpicola* and *P. Florindae*. Under garden conditions they are said to cross freely, giving flowers pale-yellow to old ivory, rosy-fawn and even cinnabar-red. Hybrids presumed to be between *P. Florindae* and *P. Waltoni* are reported as favouring the former but with pink flowers. More exact data from experimental crossing are desirable.

A sturdy perennial 30–120 cm. tall, with a short stout rootstock. Leaves including the petiole 10–50 cm. long; lamina 4–20 cm. long, 4–15 cm. broad, broadly ovate, rounded at the apex, deeply cordate at the base, subregularly dentate, lustrous above, glabrous on both surfaces but with a thin covering of potentially farinose glands below; midrib broad with lateral nerves subconspicuous; petiole 6–30 cm. long, stout, prominently winged, often tinged with red. Scape up to 120 cm. tall, glabrous, but sometimes with a little farina towards the apex, carrying an umbel (sometimes two superposed) of up to 40 flowers, even 60–80 (ex Ward, *l.c.*, 447); bracts 1–3 cm. long, broadly lanceolate to oblong, often toothed at the apex, swollen or markedly gibbose at the base, slightly farinose; pedicels 2–10 cm. long, nodding, farinose. Calyx 8–10 mm. long, campanulate, conspicuously creamy-yellow farinose, cut for a third or a little over into triangular acute and often recurved teeth. Corolla 1·5–2·5 cm. long, narrow-infundibuliform, bright sulphur-yellow, exannulate, heteromorphic, farinose without; tube slightly ampliate above insertion of stamens, more or less cylindrical for basal 8–15 mm., then gradually expanding into limb 1–2 cm. across; lobes broadly ovate or subrotund to slightly obovate, copiously creamy-yellow-farinose within, pointed, slightly retuse or crenulate at the apex. Stamens, with anthers 2 mm. long, inserted towards apex of cylindrical part of corolla-tube in thrum-eyed flowers, a little above base of tube in pin-eyed. Long style slightly exserted beyond mouth of corolla-tube; short style 1 mm. long. Capsule oblong, nearly twice as long as the calyx, dehiscing by longitudinal valves. Seeds up to 2 mm. long, irregularly rectangular to ovoid, fawn-coloured, smooth but under lens minutely reticulate or finely vesicular-surfaced.

S.E. TIBET: Rong Chu, Tumbetse (*Ward*, 5781—*co-type*); Migyitun, Tsari Chu (*Ludlow and Sherriff*, 1663); Gyara Phu Chu, near Molo (*Ludlow, Sherriff and Taylor*, 5644); Tsanang La, near Paka (*L., S. and T.*, 5877—form with reddish amber flowers); sine loc. (*L., S. and T.*, 5445).

P. ioessa W. W. Sm. in Notes Roy. Bot. Gard. Edin., xix, 216 (1937); Ludlow in Himalayan Journal, x, 14, fig. facing p. 12 (1938).

This plant is known only from S. and S.E. Tibet where it was first collected by Ward in 1935 in the Tsari district above Migyitun at 3600 m. Ward's original plants had a white corolla sometimes tinged with purple or violet and were named *P. sikkimensis subpinnatifida* (Smith, *l.c.*, xix, 173). Further material was obtained in 1936 by Ludlow and Sherriff with flowers violet to pinkish-mauve. It was not realised at the time that these specimens should be equated with the Wardian plant and they were described as *P. ioessa* (Smith, *l.c.*) which takes precedence as first specific name. But in 1938 Ludlow, Sherriff and Taylor collected a series of plants, demonstrating clearly transitions in colour from white to violet-purple. These grew together in open swampy meadows. In the original description of *P. ioessa* some doubt is expressed as to its status.

The evidence now available and the field observations of collectors well acquainted with *P. Waltoni* and with the varieties of *P. sikkimensis* serve to confirm its claim to specific rank. The nearest allies are *P. Waltoni* and *P. sikkimensis Hopeana.* From both it differs primarily in the much inflated corolla, as broad as long, but also in the almost black calyx and in the usually oblanceolate more incised leaves. It is but sparingly in cultivation from seed collected in 1938.

A perennial, efarinose except for the inflorescence, with a short stout rhizome. Leaves including the petiole 6–20 cm. long, 1–2·5 cm. broad; lamina narrowly oblong or oblanceolate to spathulate, rounded or subacute at apex, attenuate at base, serrate-dentate to subregularly incised-dentate, chartaceous, glabrous, efarinose, midrib conspicuous with slender lateral nerves; petiole shorter than or subequal to lamina, slightly winged, sheathing at base. Scape 10–30 cm. tall, sturdy, slightly farinose at apex, carrying an umbel of 2–8 flowers; bracts 0·5–1·5 cm. long, linear to linear-lanceolate, often covered with purplish striae, faintly farinose; pedicels 1–6 cm. long, slender, yellow-farinose especially at apex. Calyx 6–10 mm. long, campanulate to tubular-campanulate, almost black, slightly farinose without, more copiously within, strongly 5-veined, cut to middle or almost so into triangular acute often recurved lobes. Corolla 2–2·5 cm. long and broad, pale madder-pink or pinkish-mauve to violet, infundibuliform; tube cylindrical, 1–2 times the calyx, quickly widening out into limb; lobes broadly obcordate, emarginate or subentire, evenly coated with farina within. Stamens, with anthers 1·5 mm. long, inserted at apex of corolla-tube in thrum-eyed flowers, 3 mm. from base in pin-eyed. Long style equalling corolla-tube; short style 2 mm. long. Capsule cylindrical, subequal to or shorter than calyx, dehiscing by longitudinal valves.

The type is in the British Museum Herbarium and at Edinburgh are:—

S.E. Tibet: Migyitun, Tsari (*Ludlow and Sherriff*, 2514—*co-type*); Bimbi La, Tsari (*L. and S.*, 1791); Tama La, Tsari (*L. and S.*, 2189, 2571); Singo Samba, Lo La Chu, near Molo (*L. and S.*, 1868, 2672; *Ludlow, Sherriff and Taylor*, 3789); Tsari Sama, Langong (*L., S. and T.*, 5537, 5538, 5540, 5541).

P. ioessa W. W. Sm. var. **subpinnatifida** (W. W. Sm.). Comb. nov. *P. sikkimensis* subsp. *subpinnatifida* W. W. Sm. in Notes Roy. Bot. Gard. Edin., xix, 173 (1936). *P. sikkimensis* var. *sub-*

pinnatifida W. W. Sm. in *ibid.*, xix, 218 (1937). *P. Hopeana* W. W. Sm. in *ibid.*, xix, 216 (1937)—nec Balf. f. et Cooper.

Differing from the type only in the colour of the flowers which are white to creamy-white, sometimes tinged with purple or violet.

S.E. TIBET: Tse Gar, above Migyitun, Tsari (*Ward*, 11931—*co-type* of *P. sikkimensis* subsp. *subpinnatifida*, 11930); Migyitun, Tsari (*Ludlow and Sherriff*, 1686); Chickchar, Tsari (*L. and S.*, 2141, 2490); Takar La, West Tsari (*L. and S.*, 2075, 2240); Chiniung La, Langong (*L., S. and Taylor*, 5609); Langong, Langong Chu (*L., S. and T.*, 3880); Langong, Tsari Sama (*L., S. and T.*, 5539).

P. reticulata Wall. in Roxb. Fl. Ind., ii, 21 (1824); Duby in DC. Prodr., viii, 41 (1844); Hook. f. in Fl. Brit. Ind., iii, 483 (1882); Pax in Engl. Bot. Jahrb., x, 215 (1889); Gard. Chron., i, 777, 803 (1887); *ibid.*, iii, 781 (1888); Watt in Journ. Roy. Hort. Soc., xxix, 7, 21, 27 (1904), and in *ibid.*, xxxix, 202, 212, 215–217 (1913); Pax in Engl. Pflanzenr. Primulaceae, 120, fig. 34A (1905); Craib in Journ. Roy. Hort. Soc., xxxix, 189 (1913); W. W. Sm. and Forrest, *ibid.*, liv, 42 (1929), and in Notes Roy. Bot. Gard. Edin., xvi, 39 (1928); Basu, Ind. Med. Plants, t. 575 (1918); Bruun, Cytological Studies in Primula, 94, 127 (1932). *P. altissima* G. Don, Prodr. Fl. Nepal., 78 (1825). ? *P. speciosa* G. Don, *l.c.*

The first of the section to be described, this species was secured by Dr. Wallich on his expedition to Nepal in 1820. The specimens were brought from Gossain Than by pilgrims as Wallich was not permitted access to that sacred area. In his description no affinity is suggested for the plant and indeed at that time the Himalayan flora was practically unknown. Hooker (*l.c.*) collected it in Sikkim and gave it its true place as a close ally of *P. sikkimensis*. Pax (*l.c.*) included it in his section Cordifoliae, attaching too much weight to the leaf-shape which here has no phyletic significance. The cytological analysis of Bruun (*l.c.*) is entirely in favour of Hooker's opinion. The species is not uncommon in Nepal and Sikkim at 3500–5000 m., and occurs more sparingly in S. Tibet and W. Bhutan. The cordate leaves with very long and distinct petioles separate it readily from *P. sikkimensis*; the oblong fiddle-shaped lamina from *P. firmipes*. The names given to two Wallichian plants from Gossain Than by Don (*l.c.*), *P. altissima* and *P. speciosa*, are usually quoted as synonymous and in all probability correctly so as regards the former, but as Don's type material is no longer extant, it is not possible to confirm the reduction. Seeds obtained from the Chumbi

Valley, Tibet, by Sir George King in 1886 gave rise to flowering plants in this country in 1887 (Gard. Chron., *l.c.*). The species has been in cultivation since, perhaps intermittently, and still persists.

A stout to slender plant with usually a short rhizome. Leaves including the petiole 4–40 cm. long; lamina 2–10 cm. long, oblong to ovate-oblong, rounded at the apex, cordate at the base, dentate or crenate-dentate or doubly crenate, smooth or slightly rugose above, glabrous or faintly pubescent below; midrib conspicuous; veins forming a fine reticulum, slightly sunk above, prominent below; petioles up to 30 cm. long, 3–4 times longer than the lamina. Scape 18–45 cm. tall, at first slender, later more robust, farinose towards the apex, carrying few or many flowers, the outer generally nodding, the inner more or less erect; bracts 7–20 mm. long, linear-lanceolate or lanceolate to ovate, occasionally toothed, farinose; pedicels 1–5 cm. long, slender, farinose. Calyx 5–12 mm. long, campanulate to tubular-campanulate, farinose both within and without, conspicuously 5-angled, divided for a third to a half into lanceolate acute and often recurved lobes. Corolla yellow or white, exannulate, heteromorphic; tube cylindrical, usually twice as long as calyx, sometimes only a little longer; limb 1–2 cm. across, evenly coated with farina within; lobes obovate, slightly emarginate or undulate. Stamens, with anthers 2 mm. long, inserted near the middle of corolla-tube in pin-eyed flowers and towards apex in thrum-eyed. Long style as long as tube or slightly exserted; short style not as long as calyx. Capsule cylindrical, equalling or slightly longer than calyx, dehiscing by longitudinal valves. Seeds 1 mm. in diameter, smaller than those of *P. sikkimensis* but otherwise similar.

Wallich's original plants are represented at Kew, the British Museum, and Calcutta, and in Edinburgh are:—

NEPAL: Gossain Than (*Wallich—co-type*); near Gossain Than (*Lal Dhwoj*, 4, 230, 231); Michet (*L. D.*, 3A, 6A); (*Sharma*, 342); Tangba (*Lal Dhwoj*, 136); Jekkarka (*Sharma*, 78); Dalkhark (*S.* 479); Jeyjey (*S.* 386); Baituk (*S.* 345).

SIKKIM: Kapoop (*Rhomoo Lepcha*, 26); Megu (*R. L.*, 801, 821); (*Cave*, 11); Changu (*Cooper*, 8, 87, 540); Dobinda Pass (*C.* 344); Phedup (*Cave* in 1916); Tari (*C.* in 1914); Nathu La (*Bailey* in 1925); Zemu Valley (*Smith and Cave*, 1128); Yak-la (*King's Collector*, 4503).

BHUTAN: Parshong Timpu (*Cooper*, 1987).

S.E. TIBET: Nagu Chu (*Ludlow, Sherriff and Taylor*, 5762).

P. secundiflora Franch. in Bull. Soc. Bot. Fr., xxxii, 267 (1885): Pax in Engl. Bot. Jahrb., x, 206 (1889); Forbes and Hemsl. in Journ. Linn. Soc., xxvi, 42 (1889); Pax in Engl. Pflanzenr. Primulaceae, 106 (1905); Gard. Chron., li, 281, fig. (1912); *ibid.*, lv, 364, fig. 158 (1914); Ward, *ibid.*, lxxxii, 173–4 (1927); Balf. f. in Journ. Roy. Hort. Soc., xxxix, 159, fig. 62 (1913); *ibid.*, xl, Proc., p. cxxx, fig. 62 (1914); Forrest, *ibid.*, xli, 207, fig. 78 (1915); Forrest, *ibid.*, xlii, fig. 16 (1916); W. W. Sm. and Forrest, *ibid.*, liv, 42 (1929); Hand.-Mzt., *ibid.*, liv, 58 (1929); McLaren, *ibid.*, liv, 67 (1929); Gould, *ibid.*, liv, 74 (1929); Adamson, *ibid.*, liv, 82 (1929); W. W. Sm. and Forrest in Notes Roy. Bot. Gard. Edin., xvi, 39 (1928); Bruun, Cytological Studies in Primula, 96–97, 127 (1932). *P. vittata* Bur. et Franch. in Journ. de Bot., v, 96 (1891); Pax in Engl. Pflanzenr. Primulaceae, 118 (1905); Gard. Chron., xxxvii, 390, fig. 165 (1905); *ibid.*, xl, 230, fig. 87 (1906); Ward, *ibid.*, lxxxviii, 32 (1930); Jardin, xxii, 184, fig. 100 (1908); Bot. Mag., t. 8586 (1914); Tribune Hort., ix, t. 419 (1914); Farrer. English Rock Garden, ii, 180 (1919); Journ. Roy. Hort. Soc., xxxi, Proc., p. cxxix (1906); Balf. f., *ibid.*, xxxix, 159, fig. 63 (1913); *ibid.*, xlii, 36 (1916); Ward, *ibid.*, xlviii, 205 (1923); W. W. Sm. and Forrest, *ibid.*, liv, 42 (1929); Hand.-Mzt., *ibid.*, liv, 58 (1929); McLaren, *ibid.*, liv, 67 (1929); Gould, *ibid.*, liv, 74 (1929); Adamson, *ibid.*, liv, 82 (1929); W. W. Sm. and Forrest in Notes Roy. Bot. Gard. Edin., xvi, 39 (1928); Bruun. Cytological Studies in Primula, 96, 127 (1932).

The first description of this species is based on specimens collected by Abbé Delavay in 1884 near the glaciers of the Lichiang Range in Yunnan at 3500–4000 m. The type, *Delavay* 3, is in the Paris Herbarium. Franchet placed his plant near *P. sikkimensis* and aptly so. When, however, a few years later along with Bureau (*l.c.*) he described under *P. vittata* very similar material obtained by Prince Henri d'Orleans from moist meadows between Batang and Litang in Szechwan, the authors made comparison with *P. Stuartii* and *P. Kingii* and expressed the view that the latter and *P. vittata* were possibly only extreme varieties of *P. Stuartii*. Pax in his Monograph (*l.c.*) transferred *P. secundiflora* to association with *P. Stuartii* in his section Nivales and relegated *P. vittata* with much doubt to Callianthae. Balfour (*l.c.*) at the Primula Conference of 1913 included both in his then constituted section Sikkimensis, noting moreover their very close approach to one another. They continued to be quoted together, *P. secundiflora* being regarded as the more alpine plant with a few-flowered inflorescence and a flattish rosette of short leaves, and *P. vittata* as coming from lower elevations with numerous flowers and longer leaves. Ample field collections from S.W. Szechwan and N.W. Yunnan show that the distribution is continuous and that the distinctions are almost certainly due to environment. Experience in cultivation affords no data for discrimination. *P. secundiflora* is readily recognised among the members of the section by the shape and quality of its usually short-petioled leaves, by the calyx and corolla, and by the somewhat strongly vesicular-surfaced seeds. Although its characters are quite in consonance with those of the section, it appears to stand a little apart from its allies. The cytological data (Bruun, *l.c.*) indicates for this species a certain degree of divergence in what is otherwise a very uniform section. The species flowered for the first time in this country in 1905 when Messrs Veitch gained an Award of Merit for plants raised from seed collected by E. H. Wilson (Gard. Chron., xxxvii, 390). It is a beautiful plant and is still to be found in many gardens.

A sturdy efarinose or slightly farinose perennial with a short stout rhizome. Leaves 3–30 cm. long including the petiole; blade 1–4 cm. broad, oblong or oblong-elliptic to obovate or oblanceolate, obtuse or acute or rounded at the apex, tapering into the petiole generally very short and prominently winged but sometimes in autumn equalling blade, finely crenate to deeply crenate-serrate at the margin, glabrous, when young often obviously yellow-farinose below but at maturity seemingly efarinose yet thinly beset with farina-glands; midrib broad with fairly distinct lateral nerves. Scape 10–90 cm. tall, stout, white-farinose towards the apex, carrying a terminal umbel of 5–20 nodding reddish-purple or deep rose-red flowers, or sometimes two superposed umbels; bracts 5–10 mm. long, lanceolate, acute, green and flushed with purple except at the base, farinose especially within; pedicels 1–5 cm. long, slender, farinose, stiff and erect in fruit. Calyx 7–10 mm. long, campanulate to tubular-campanulate, thickly coated with white farina within, cut to about the middle into lanceolate or triangular-lanceolate acute lobes, white-farinose at the margin, longitudinally 10-vittate, 5 of the vittae glabrous purple and continued into the lobes, the other 5 white-farinose. Corolla 1·5–2·5 cm. long, exannulate, heteromorphic, infundibuliform; tube ampliate above the insertion of the stamens, narrow and cylindrical for the length of the calyx in thrum-eyed flowers and for the basal 2–3 mm. in pin-eyed, then gradually widening upwards into the limb; limb 1·5–2·5 cm. across with obovate-oblong lobes rounded or slightly retuse at the apex. Stamens, with anthers 2 mm. long, inserted 2–3 mm. above base of corolla-tube in pin-eyed flowers and about 10 mm. above base in thrum-eyed. Long style 8–9 mm. long; short style 2–3 mm. long. Capsule elliptical to oblong, usually half as long again as calyx, dehiscing by longitudinal valves. Seeds 1 mm. in diameter, irregularly quadrate, vesicular-surfaced.

In the Edinburgh Herbarium are:—

YUNNAN: Lichiang Range (*Delavay*, 3—*co-type*); (*Forrest*, 2283, 5913, 10324, 10498, 28215, 28222, 30315); (*Rock*, 24807, 24847, 25300); between Lichiang and Yungning (*R.* 17209); mountains in the N.E. of the Yangtze bend (*Forrest*, 10497); Mekong-Yangtze divide (*F.* 25698); divide between Yungning and Yangtze valleys (*F.* 21285); Mekong-Salwin divide, Mount Fuchuan (*Rock*, 18392); mountains near Atuntze (*Forrest*, 20197, 22776, 22783); (*Ward*, 99); mountains west of Fengkou valley (*Forrest*, 12484); Chungtien plateau (*F.* 12710); (*Rock*, 17273, 24613, 25245); Moting Shan (*R.* 23348); Yulung Shan (*R.* 24977, 25369); Bei-ma Shan (*R.* 22845); (*Forrest*, 14521); Shui Mun Kai (*F.* 30219); Chiusa Shan (*F.* 30237); Goo-du Shan (*F.* 20521); without precise locality (*F.* 15207, 15323, 25903, 28652, 28763, 29133).

SZECHWAN: Near Tatsienlu (*Pratt*, 59); (*Wilson*, 3159); (*Harry Smith*, 10603); north of Chiu-Lung-Hsien, S.W. of Tatsienlu (*Rock*, 17462); Tongolo (*Soulié*, 934, 2923); mountains E. of Yungning (*Forrest*, 20487); Yungling (*F.* 30240, 30247); mountains around Muli (*F.* 28413, 30283); Mount Gibboh, S. of Muli (*Rock*, 16028); S. of Dzampe Sheren, Muli (*R.* 23795, 24352); Kaushu Shan, S.W. of Muli (*R.* 24091, 24093, 24472, 24490); Mount Mitzuga, W. of Muli Gomba (*R.* 16066, 16071, 16167, 24022, 24023, 24545); Mount Siga, N.E. of Kulu (*R.* 17879, 18120, 23832, 24401); mountains of Yetsi (*R.* 23916, 24417); near Yedo (*Cunningham*, 618); Sikang, between Taining and Taofu (*Harry Smith*, 12039).

TIBET: Upper Yigrong valley (*Ward*, 12228).

P. sikkimensis Hook. in Bot. Mag., t. 4597 (1851); Lem. Jard. Fl., ii, t. 169 (1851); Walpers, Ann., v, 465 (1858); Regel in Gartenflora, xxv, 321, t. 882 (1876); Hook. f. in Fl. Brit. Ind., iii, 491 (1882); Franch. in Bull. Bot. Soc. Fr., xxxii, 268 (1885); Pax in Engl. Bot. Jahrb., x, 207 (1889); Forbes and Hemsl. in Journ. Linn. Soc., xxvi, 42 (1889); Pax in Engl. Pflanzenr. Primulaceae, 100, fig. 29*a* (1905); The Garden, xx, 421, with fig. (1881); *ibid.*, lxii, figs. pp. 82, 113 (1902); *ibid.*, lxxix, fig. p. 161 (1915); *ibid.*, lxxxiii, fig. p. 165 (1919); *ibid.*, lxxxiv, fig. p. 576 (1920); Ward, *ibid.*, lxxxix, 446, with fig. (1925); Journ. Hort., ix, fig. p. 123 (1885); *ibid.*, xii, fig. p. 275 (1886); *ibid.*, xlix, fig. p. 571 (1904); Tribune Hort., iv, 365 (1909); *ibid.*, ix, 245 (1914); Watt in Journ. Roy. Hort. Soc., xxix, 299, 301, 314 (1904); Wilson, *ibid.*, xxix, 660 (1905); Balf. f., *ibid.*, xxxix, 160, fig. 65 (1913); Farrer, English Rock Garden, ii, 183, fig. 24 (1919); Ward in Gard. Chron., lxxxii, 172, fig. 78A (1927); W. W. Sm. and Forrest in Notes Roy. Bot. Gard. Edin., xvi, 39 (1928); Journ. Roy. Hort. Soc., liv, 42, 57, 67 (1929); Stapf in Bot. Mag., sub. t. 9210 (1930), and in *ibid.*, sub. t. 9276 (1932); Sherriff and Taylor in Bull. Alp. Gard. Soc., viii, 118, fig. p. 123 (1940). *P. sikkimensis Hookeri* Stapf in Bot. Mag., sub. t. 9276 (1932). *P. microdonta* Franch. ex Petitmengin in Bull. Herb. Boiss., vii, 526, fig. p. 525 (1907); Balf. f. in Journ. Roy. Hort. Soc., xxxix, 135, 159, 160 (1913); W. W. Sm. and Forrest in *ibid.*, liv, 42 (1929), and in Notes Roy. Bot. Gard. Edin., xvi, 39 (1928). *P. pseudosikkimensis* Forrest in Notes Roy. Bot. Gard. Edin., xiv, 52 (1923); Ward in Land of the Blue Poppy, t. 22 (1913); Balf. f. in Journ. Roy. Hort. Soc., xxxix, 136, 159, fig. 64 (1913); Forrest, *ibid.*, xli, 207, fig. 78 (1915); The Garden, lxxvii, 303, with fig. (1913); Ward, *ibid.*, lxxxix, 446 (1925); Tribune Hort., ix, t. 419 (1914); Hand.-Mzt., Naturbilder, S.W. China, 76 (1927); Cox and Taylor, Primulas, 112 (1928); Journ. Roy. Hort. Soc., xl, 176 (1914); Ward, *ibid.*, xlviii, 205 (1923); *ibid.*, liv, 42, 57, 59, 74 (1929). *P. sikkimensis* subsp. *pseudosikkimensis* (Forrest) W. W. Sm. et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 39 (1928), and in Journ. Roy. Hort. Soc., liv, 42 (1929). *P. sikkimensis pseudosikkimensis* Stapf in Bot. Mag., sub. t. 9276 (1932). *P. penduliflora* Kern. ex Stein in Samenkat. Bot. Gard. Breslau (1881).

This well-known species was one of the many discoveries of Sir Joseph Hooker during his memorable exploration of Sikkim in 1848–9. Seed forwarded by him to Kew produced flowering plants which formed the basis of Sir William Hooker's description in 1851 (Bot. Mag., *l.c.*). Accompanying the diagnosis is a note from the collector: "It is the pride of all the alpine Primulas, inhabits wet boggy places at elevations of from 12–17,000 feet, at Lachen and Lachong, covering acres with a yellow carpet in May and June."

It is found in the Himalaya from Nepal to Bhutan, in southern and eastern Tibet, in the Chinese provinces of Szechwan and Yunnan. and just within the frontiers of N.W. Burma. It is by far the most widespread species of the section, of which it is the typical representative. Throughout Sikkim it is very consistent in its vegetative characters and in its flower-colour. In the other areas plants are found entirely in consonance with the Sikkim one but several variations occur. Some of these appear trivial and may be due to environmental factors, while others merit more consideration. Of the former two have received specific names and can be dealt with here. *P. microdonta* Petitm. (*l.c.*) from China, Bhutan and Nepal—presumably relatively drier areas—shows a longer, more discrete petiole and a blade less decurrent and sometimes even rounded at the base. The differences are, however, fortuitous as many transitions show. *P. pseudosikkimensis* Forrest (*l.c.*) is a calciphile plant of the Lichiang Range in Yunnan—somewhat rigid in habit and with large bright yellow flowers. But when in cultivation its characters did not warrant a distinguishing name. More divergent are the three varieties discussed later.

A sturdy perennial with a short but stout rhizome. Leaves including the petiole 10–40 cm. long, 2–7 cm. broad; lamina elliptic or oblong to oblanceolate, rounded or occasionally acute at the apex, usually long attenuate at the base but sometimes obtuse or even almost rounded, serrate or crenate-serrate or dentate, shining, glabrous and efarinose though with a few potentially farinose glands below; midrib prominent with lateral veins and nervules forming an open reticulation; petiole much shorter than lamina, conspicuously winged and not clearly differentiated, or subequal and then quite distinct. Scape 15–90 cm. tall, stout and erect especially in fruit, yellow-farinose at apex, carrying usually one umbel of numerous flowers, sometimes a second; bracts 1–2 cm. long, lanceolate or linear-lanceolate, attenuate at apex, often swollen at base, yellow-farinose, striate; pedicels 2–10 cm. long, farinose, pendulous at first, a little longer and erect in fruit. Calyx 7–12 mm. long, campanulate to tubular-campanulate, conspicuously 5-nerved, copiously yellow-farinose within and without, cut to the middle or almost so into lanceolate to triangular-lanceolate, acute and recurved lobes. Corolla 2–3 cm. long, 1·5–3 cm. broad, yellow or occasionally creamy-white, exannulate, heteromorphic: tube cylindrical, 1–2 times the calyx, slightly ampliate above insertion of stamens; limb with oblong to obcordate entire or emarginate lobes, lightly powdered with farina within. Stamens, with anthers

2 mm. long, inserted at apex of corolla-tube in thrum-eyed flowers, near base in pin-eyed. Long style equals corolla-tube or almost so; short style 2 mm. long. Capsule oblong, as long as or longer than calyx, dehiscing by longitudinal valves. Seeds 1·5–2 mm. long, rectangular to ovoid, nearly smooth but under the lens reticulate-surfaced.

Material of *P. sikkimensis* is amply represented in the Edinburgh Herbarium and the specimens quoted below are a selection:—

Nepal: Tangba (*Lal Dhwoj*, 135); Tenboozey (*L. D.*, 198); Michet (*L. D.*, 2A, 5A: *Sharma*, 339); Manang (*S.* 42); Sargadangka (*S.* 81); Langdeng (*S.* 116); Selkharka (*S.* 336, 337); Ganeshkund (*S.* 348); Gossain Than (*Native Collector*, 2).

Sikkim: Changu (*Cave*, 2, 4); Jongri (*Native Collector*, 940); Yampung (*Native Collector*, 869); Nathui La (*Bailey* in 1925).

Bhutan: Lhabja Pumthang (*Cooper*, 2176); Lingshi Timpu (*C.* 1584, 1788); Rudo La (*Ludlow and Sherriff*, 293); Sakden (*L. and S.*, 599); Dungshinggang (*L. and S.*, 3297).

Tibet: Mekong–Salwin divide (*Forrest*, 400); Salwin–Kiu-chiang divide (*F.* 19226); Nagong (*Ward*, 10868); Sanga Chöling (*Ludlow and Sherriff*, 1582); Bung, Char Chu (*L. and S.*, 1966); Dotha, Chumbi Valley (*Bailey* in 1924); Tsarong (*Rock*, 22987, 23227).

N.W. Burma: Seinghku Wang (*Ward*, 6902, 7041).

Yunnan: Mountains of the Chungtien plateau (*Forrest*, 10420); Fuchuan Shan (*F.* 30222); Goo-du Shan (*F.* 20529); near Yungning (*Hand.-Mzt.*, 3195); Lankong (*Delavay* in 1886); Mount Gyi-na lo-ko (*Rock*, 25015); South of Lichiang (*R.* 25178); Lichiang Range (*F.* 2642—*type* of *P. pseudosikkimensis*, 5978, 10329, 28218); Tsekou (*Soulié*, 1327; *Mombeig*, 179); between Yungning and Yungpeh (*Schneider*, 1635).

Szechwan: S.W. of Muli (*Rock*, 24088); Muli (*R.* 16465, 24020); Batang (*Soulié*, 3406).

P. sikkimensis Hook. var. **Hopeana** (Balf. f. et Cooper). Comb. nov.

P. Hopeana Balf. f. et Cooper in Trans. Bot. Soc. Edin., xxvii, 236 (1917); Cooke in Gard. Chron., xciii, 41, fig. p. 21 (1933); Ward in Quart. Bull. Alp. Gard. Soc., vi, 303 (1938); Sherriff and Taylor, *ibid.*, viii, 119, fig. p. 124 (1940). *P. sikkimensis* subsp. *Hopeana* (Balf. f. et Cooper) W. W. Sm. et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 39 (1928), and in Journ. Roy. Hort. Soc., liv, 42 (1929).

This variety comes from Bhutan and the adjoining Tibetan frontiers, growing at 4500–5000 m. It has the appearance of a slender *P. sikkimensis* with a white (or pale yellow fading to white) corolla which is often more narrow-tubular than bell-shaped. In habit it approximates also to states of *P. Waltoni*. It was first collected by Cooper in 1915 and flowered from his seeds in cultivation in 1917. It is thus represented:—

BHUTAN: Ridge S.E. of Angduphorang (*Cooper*, 4807—*type*); Tang Chu, Ritang (*Ludlow and Sherriff*, 3227, 3228); Dungshinggang (*L. and S.*, 3316, 3317); Tibdeh La, Yuto La Range (*L. and S.*, 3488).

S.E. TIBET: Luguthang to Mago (*Ward*, 11645).

P. sikkimensis Hook. var. **lorifolia** W. W. Sm. in Notes Roy. Bot. Gard. Edin., xix, 313 (1938).

This is known only from a single specimen in the Herbarium of the British Museum collected in 1936 by Hanbury-Tracy at Lho Dzong, Kham, Eastern Tibet, at 4200 m. It is distinguished by the very narrow leaves with margins only faintly serrate. The flowers are yellow and correspond in size and structure with those of high elevation forms of *P. sikkimensis*. It is represented at Edinburgh by a photograph of the type—*Hanbury-Tracy*, 176.

P. sikkimensis var. **pudibunda** (W. W. Sm.). Comb. nov. *P. pudibunda* W. W. Sm. in Rec. Bot. Surv. Ind., vi, 38 (1913); W. W. Sm. and Ward in Notes Roy. Bot. Gard. Edin., xv, 86–87 (1926); W. W. Sm. and Forrest, *ibid.*, 253 (1927); Ward in Journ. Roy. Hort. Soc., lii, 22–23 (1927); Ward in Gard. Chron., lxxxii, 173 (1927); *ibid.*, civ, 322, fig. 138 (1938). *P. sikkimensis* subsp. *pudibunda* W. W. Sm. et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 39 (1928), and in Journ. Roy. Hort. Soc., liv, 42 (1929). *P. microdonta alpicola* f. *micromeres* W. W. Sm. et Ward in Notes Roy. Bot. Gard. Edin., xv, 86 (1926).

This was described from Sikkim material of a slender plant with very much smaller flowers than those of *P. sikkimensis*. In the last thirty years very similar specimens have been found in Nepal, Bhutan, Tibet, and West China. It can be assessed as an extreme alpine variety of *P. sikkimensis* with almost the same geographical range. *P. microdonta alpicola* f. *micromeres* (Smith and Ward, *l.c.*, 86) is now regarded as equivalent. It was collected at the same time and place as *P. alpicola* and was mistakenly deemed to be a dwarf state of the latter.

This variety is represented at Edinburgh by:—

SIKKIM: Eumtso La (*Smith and Cave*, 1614—*type*); Dobinda Pass (*Cooper*, 343); Lamtung to Tangu (*Younghusband* in 1904).

TIBET: Lalung Gompa (*White* in 1906); Khambadzong (*Younghusband*, 46); Kyi Chu Valley (*Walton* in 1910); Chiniung La, near Langong (*Ludlow, Sherriff and Taylor*, 3932); Sang La (*Ward*, 5939—*pro parte*—*co-type* of *P. alpicola microdonta* f. *micromeres*).

NEPAL: Bikhoo Shailoong (*Lal Dhwoj*, 405); Old Duab Kund (*L. D.*, 234).

BHUTAN: Lhakang (*Ludlow and Sherriff*, 516); Yelé La, Timpu (*Cooper*, 1838).

SZECHWAN: near Tatsienlu (*Pratt*, 253).

P. Waltoni Watt MSS. ex Balf. f. in Notes Roy. Bot. Gard. Edin., ix, 57 (1915); Ward in The Garden, lxxxix, 446 (1925); Ward, Riddle of Tsangpo Gorges, 24, 32, 156 (1926); Ward in Gard. Chron., lxxxii, 172–174, fig. 78B (1927); Harley, *ibid.*, lxxxii, 51, fig. 22 (1927); Ward, *ibid.*, lxxxviii, 32 (1930); Ward in Journ. Roy. Hort. Soc., lii, 18, 22 (1927); *ibid.*, liv, 1, 42, 67, 74, 83 (1929); W. W. Sm. and Ward in Notes Roy. Bot. Gard. Edin., xv, 87, 91, 95 (1926); W. W. Sm. and Forrest, *ibid.*, xvi, 39 (1928); Stapf in Bot. Mag., sub. t. 9210 (1930) and sub. t. 9276 (1932); Bruun, Cytological Studies in Primula, 96, 127 (1932). *P. prionotes* Balf. f. et Watt in Notes Roy. Bot. Gard. Edin., ix, 35 (1915); Ward in The Garden, lxxxix, 447 (1925); Ward in Gard. Chron., lxxxii, 172–174, fig. 78C (1927); Ward, *ibid.*, lxxxviii, 32 (1930); *ibid.*, cvi, 213 (1939); Journ. Roy. Hort. Soc., liv, 67, 83 (1929); Bruun, *l.c.*, 96, 127 (1932). *P. Waltoni* subsp. *prionotes* (Balf. f. et Watt) W. W. Sm. et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 39 (1928), and in Journ. Roy. Hort. Soc., liv, 42 (1929). *P. vinosa* Stapf in Bot. Mag., sub. t. 9276 (1932), *in clavi*; Stapf, *ibid.*, t. 9210 (1930)—fig. only. *P. vinosa* vel aff. W. W. Sm. in Notes Roy. Bot. Gard. Edin., xix, 218 (1937). *P. sikkimensis microdonta* Stapf in Bot. Mag., t. 9210 (1930)—*pro parte*. *P. sp.* (Ruby Primula) Ward in The Garden, lxxxix, 447 (1925).

The first collection of this species was made in August 1904 from hills above Lhasa by Captain H. J. Walton, I.M.S. Watt marked it as new but description came from Balfour in 1915. The material then available was far advanced in fruit with corollas much shrivelled. Nothing more was known of the species until in 1924 Ward collected on the Nambu La in S.E. Tibet specimens

(*Ward* 6094) which were referred to *P. Waltoni* (Smith and Ward, *l.c.*, 87). Plants so named were raised from Ward's seed and have been in various gardens since 1925. However, in 1930, a description was given (Bot. Mag., 9210) of a similar Wardian plant by Stapf under the name *P. sikkimensis microdonta*. But Stapf a little later (1932) changed his view and in publishing *P. alpicola* (Bot. Mag., 9276) indicated that the previous figure (9210) represented a new species which he called *P. vinosa*, associating therewith *Ward* 6094.

Walton also collected in 1904 another plant of this section at 5800 m. on the Karo La, which lies between Lhasa and the Sikkim frontier. This too was considered by Watt to be new and described later by Balfour (*l.c.*) as *P. prionotes* but without any reference to *P. Waltoni* in the diagnosis. In 1928 *P. prionotes* was placed provisionally as a subspecies of *P. Waltoni* in the list published by Smith and Forrest (*l.c.*). It was introduced about the same time as *P. Waltoni*, the seed being obtained from Gyantze. It has the appearance of a slender state of *P. Waltoni* and grows in a more arid area and at a higher elevation. It has a narrower corolla than *P. vinosa*; the size of the corolla in *P. Waltoni* is imperfectly known. The three plants, *P. Waltoni*, *P. vinosa*, and *P. prionotes* are almost wholly Tibetan; *P. vinosa* is found about 150 miles to the S.E. of Lhasa and *P. prionotes* about half that distance to the S.W. of that city. There is nothing to differentiate them in the vegetative features nor in the general structure of the inflorescence. *P. vinosa* and *P. prionotes*, both in culture, are similar in flower-colour and in the peculiar banding in the interior of the corolla, farinose above and rosy-purple below, but, as noted above, the corolla in *P. vinosa* is more inflated. These dimensional variations can, however, be seen in *P. sikkimensis* without warranting specific distinctions. We incline therefore to the view that only one species is here concerned. Better material of the Lhasa plant would solve the problem. The cytology (Bruun, *l.c.*) supplies no data serving to distinguish *P. Waltoni* in its section.

Akin to *P. Waltoni* is *P. ioessa*, but that species comes nearer to forms of *P. sikkimensis*. If the latter were given a very wide definition, it could include both *P. Waltoni* and *P. ioessa* and thus become a very polychrome species. Attempts in that direction have not proved satisfactory.

A perennial plant with short stout rootstock. Leaves including the petiole 8–30 cm. long, 2–7 cm. broad; lamina elliptic-oblong to oblanceolate, rounded at the apex, cuneate at the base, erose-dentate or crenate to sharply serrate, glabrous and efarinose but with a few potentially farinose glands on the lower surface; midrib prominent above, very conspicuous below, with lateral nerves and reticulation distinct especially at late flowering and fruiting stage; petiole shorter than or subequal to lamina, usually winged, sheathing at base. Scape 20–70 cm. tall, robust or slender, slightly yellow-farinose at apex, carrying an umbel of few or many flowers; bracts 1–2 cm. long, lanceolate to linear-subulate, deeply stained purple, faintly powdered with farina, swollen or subsaccate at base; pedicels 1–7 cm. long, more or less nodding at flowering time, elongating slightly and becoming erect in fruit, farinose especially at apex. Calyx 5–10 mm. long, campanulate, farinose within and without, often deeply stained purple especially in the region of the five prominent nerves, cut for a third to a half into triangular or lanceolate acute and often recurved lobes. Corolla 1·5–3 cm. long, 0·5–2 cm. broad, pink to dull dark lilac to deep wine purple, exannulate, heteromorphic; tube as long as or two to three times the calyx, cylindrical, ampliate above insertion of stamens; limb narrowly or broadly funnel-shaped with entire or emarginate lobes, evenly powdered with white or yellowish meal within, leaving an even band around the throat and showing a rosy centre. Stamens, with anthers 2 mm. long, inserted towards base of corolla-tube in pin-eyed flowers, near apex in thrum-eyed. Long style equalling corolla-tube; short style about 1 mm. long. Capsule cylindrical, as long as or a little longer than calyx, dehiscing by 5 longitudinal valves. Seeds 1–1·5 mm. long, ovoid or angled, brown under lens, articulate-surfaced.

The type is in the Calcutta Herbarium and the following in Edinburgh:—

Tibet: Hills above Lhasa (*Walton* in 1904—*co-type*); Karo La (*Walton* in 1904—*co-type* of *P. prionotes*); Gyantze (*Bailey* in 1924); Gokar La (*Bailey* in 1924); Nambu La (*Ward*, 6094—*co-type* of *P. vinosa*); Kyimdong Dzong (*Ludlow and Sherriff*, 1832); Mago (*L. and S.*, 724).

Bhutan: Sakden (*Ludlow and Sherriff*, 598).

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THE GENUS PRIMULA: SECTION SOULIEI Balf. fil.

By W. WRIGHT SMITH and H. R. FLETCHER.

(Read 17th June 1943.)

The representative species of this section is *P. Souliei* Franch. In the original diagnosis Franchet (1) did not associate the plant with any other species beyond stating that it differed from *P. kialensis* in the scabrous leaves without farina, in the more or less cordate oval blade, and in the slender unwinged petiole. But as he compared *P. kialensis* with *P. cuneifolia* and *P. modesta*, the allocation of *P. Souliei* was still vague. Previously Franchet (2) had described *P. incisa* with much cut scabrous leaves, placing it near *P. involucrata*. But in dealing with *P. Souliei* he apparently saw in it no link with *P. incisa*. Subsequently Diels (3) referred the latter to Farinosae. Pax (4) in his Monograph did not accept this allocation and considered *P. incisa* to belong manifestly to his section Soldanelloideae, while *P. Souliei* was set far apart in the miscellaneous section Macrocarpae. In 1913 at the Third Primula Conference Balfour (5) in a tentative analysis of the Chinese species made *P. Souliei* the centre of a small group which included *P. flava* and *P. urticifolia*, while he retained with doubt *P. incisa* within Soldanelloideae. The claim of *P. Souliei* and its allies to sectional status received support from Balfour (6) in 1915 when he described *P. oresbia* and *P. rupicola*, placing the latter definitely in section Souliei and the former in Incisa (nomen). But in 1920 from his diagnosis of *P. pectinata* (7) it can be inferred that he had recognised the close relationship of *P. Souliei* and *P. incisa*.

Balfour's section was given a more definite outline at the Fourth Primula Conference in 1928 by Smith and Forrest (8). As their statement is in some measure a diagnosis of the section, the pertinent part is here cited. "This is a small section of closely allied plants and finds its nearest affinity with certain members of the Farinosae. It shows kinship with *P. yunnanensis* and *P. gemmifera*. In a general way the section can be distinguished from the dominant Farinosae by the long and distinct petioles, by the thin texture of the membranous leaves which usually show a fine scabridity on the upper surface while the lamina is moreover either markedly serrate or even deeply and pinnatifidly cut; the bracts of the pendent and usually secund flowers are non-saccate, as in *P. yunnanensis* and *P. gemmifera*. The section shows great variation in the degree of marginal indentation. Thus *P. Souliei* with little serration and *P. incisa* where the cutting is very marked are connected together by a regular series of intermediates, some of which have received specific names." The content of the section, as stated provisionally by Smith and Forrest, has required modification. *P. laciniata*, erroneously quoted as a synonym of *P. incisa*, has been shown by Smith (9) to merit specific status and to find its proper position near *P. gemmifera* within Farinosae. *P. urticifolia*, with leaves superficially suggestive of this section, has been relegated by Smith and Fletcher (10) to Farinosae, in proximity to *P. sibirica*. Additions to the section are the recently described *P. Aliciae* and *P. longipinnatifida*.

It must be admitted that the criteria invoked to separate the section from Farinosae are not completely diagnostic. The members of the section are, however, too alien in facies to be accommodated satisfactorily in the larger aggregate. With no other section is relationship indicated. Only *P. rupicola* has been examined cytologically. Bruun (11) considers that it shows a distinct cytological type, related no doubt to Farinosae, but apparently not to be associated directly with *P. yunnanensis* or other members of that section. Whether the other species are in conformity cannot yet be affirmed. The seed characters are known for *P. Aliciae*, *P. incisa* var. *florida*, and *P. rupicola*. They are in agreement for these three and diverge from what is found in *P. yunnanensis* and its near allies. The seeds are small, about 0·6 mm. in diameter, irregularly quadrate, and vesicular-surfaced.

Material for complete analysis of the section is not available and the content as here accepted may not be homogenous. *P. humilis* and *P. xanthopa* are somewhat aberrant. There is much variation in the incidence of farina. When Franchet (1) (2) described the first species of the section, *P. incisa* and *P. Souliei*, he noted particularly the scabridity of the leaves and emphasised the absence of farina. The type specimens came from Szechwan, at no great distance from Tatsienlu. Collections subsequently received from the same area prove that these two species may be efarinose, slightly farinose or again densely white-farinose on the under surface of the leaves. Consequently some of the plants described later as species and differentiated from the two leaders by the character of the farina must be given a lesser status.

The distribution of the section is chiefly in the western provinces of China, with extensions into the eastern parts of Tibet and the Himalaya. The species are difficult in cultivation. *P. rupicola* and *P. incisa* var. *florida*, raised from Forrest's seeds, persisted until 1938–9. A few plants of *P. Aliciae* still survive at this date.

References.

(1) Franchet in Journ. de Bot., ix, 450 (1895).
(2) Bull. Soc. Bot. Fr., xxxiii, 69 (1886).
(3) Engl. Bot. Jahrb., xxix, 521 (1900).
(4) Engl. Pflanzenr. Primulaceae, 66, 112 (1905).
(5) Journ. Roy. Hort. Soc., xxxix, 153, 158 (1913).
(6) Notes Roy. Bot. Gard. Edin., ix, 1, 32, 41 (1915).
(7) *Ibid.*, xiii, 15 (1920).
(8) *Ibid.*, xvi, 41 (1928), and Journ. Roy. Hort. Soc., liv, 30 (1929).
(9) *Ibid.*, xvi, 231 (1931), and Bot. Mag., 9584 (1939).
(10) Trans. Roy. Soc. Edin., lxi, 1 (1943).
(11) Cytological Studies in Primula, 58, 128 (1932).

KEY TO THE SPECIES OF SECTION SOULIEI.

A. Corolla-lobes deeply emarginate:
  B. Inflorescence loose. Pedicels 2–3 times longer than bracts:
    C. Leaves ± ovate, ± cordate to truncate at base, finely dentate or crenulate. Farina absent or white: (Szechwan)
      D. Calyx 6–9 mm. long . . . . *Souliei*
      DD. Calyx 4–6 mm. long . . . . . *Souliei* subsp. *Legendrei*
    CC. Leaves ± oblong or oblong-lanceolate, cuneate at base, coarsely toothed. Farina usually yellow:
      D. Calyx large, 7–12 mm. long. Leaves irregularly dentate, very scabrid (W. China) . . . . *rupicola*
      DD. Calyx small, 4–5 mm. long. Leaves deeply and raggedly incised, ± glabrous (Bhutan) . . . . . . *xanthopa*
  BB. Inflorescence subcapitate. Pedicels equal to or less than bracts:
    C. Petiole much shorter than blade. Calyx 8–10 mm. long (Tibet). *Aliciae*
    CC. Petiole equalling or longer than blade. Calyx 4–6 mm. long (W. China):
      D. Corolla-lobes 5–7 mm. long. Leaves deeply incised . *incisa*
      DD. Corolla-lobes 2 mm. long. Leaves almost pinnate. *longipinnatifida*
AA. Corolla-lobes entire (Szechwan) . . . . . . *humilis*

P. Aliciae Taylor MSS. ex W. W. Sm. in Journ. Linn. Soc., lii, 336 (1942).

This species is as yet known from only one valley in S.E. Tibet where it was collected in 1938 by Ludlow, Sherriff and Taylor, growing on grassy rock shelves at 4800 m. Its scabrid leaves and its flower-structure are in conformity with the sectional characters. It has no very near ally in the section and can be readily distinguished from *P. rupicola*, as well as from *P. xanthopa* with which in the original diagnosis it was compared. Seeds forwarded by Sherriff produced flowering plants in April 1940 in the garden of Mr. R. B. Cooke of Corbridge-on-Tyne. Plants from the same source flowered at Edinburgh in September 1940 and the species has still a slender hold in cultivation.

A scabrid-pubescent farinose plant up to 18 cm. tall with a short stout rootstock and generally clothed at the base with the withered remains of old foliage. Leaves 2–4 cm. long, 0·5–1·5 cm. broad, obovate to spathulate, rounded at the apex, tapering at the base into the very short winged petiole, conspicuously dentate, markedly scabrid on the upper surface and on the lower surface mostly along the veins, covered below with potentially farinose glands or with a pale yellow farina; midrib broad and distinct with 5–6 pairs of slender lateral nerves. Scape 6–18 cm. tall, faintly farinose at the apex, carrying a compact umbel of 2–6 flowers; bracts 5–12 mm. long, narrowly lanceolate or oblanceolate to sublinear, subfoliaceous, sparsely farinose and often covered with small purplish-black striae; pedicels 1–5 mm. long, with a little farina. Calyx 8–10 mm. long, more or less narrowly campanulate, farinose both within and without and sometimes marked with purplish striae, cut to the middle or slightly beyond into ovate or ovate-oblong lobes, rounded or obtuse and often toothed at the apex. Corolla pale lavender to deep violet-blue with a white-farinose eye and a ruddy-purple tube, exannulate, heteromorphic; tube cylindrical, ampliate above the insertion of the stamens, in short-styled flowers twice as long as the calyx, barely twice as long in long-styled flowers; limb 2 cm. across, somewhat concave, with broadly obcordate deeply emarginate lobes. Stamens, with anthers 1 mm. long, inserted near apex of corolla-tube in thrum-eyed flowers and near middle in pin-eyed. Long style nearly as long as corolla-tube; short style about two-thirds the calyx. Capsule shortly oblong, 7–8 mm. long, dehiscing by 5 valves. Seeds 0·6–0·7 mm. in diameter, irregularly quadrate, vesicular-surfaced.

The type is in the British Museum. The species is thus represented in Edinburgh:—

S.E. TIBET: Valley above Tripe (*Ludlow, Sherriff and Taylor*, 5423—*co-type*, 5423A).

P. humilis Pax et K. Hoffm. in Fedde Rep. Nov. Spec., xvii, 94 (1921); Hand.-Mzt., Medd. Göteb. Bot. Trädg., ii, 109 (1925–26). *P. Souliei* subsp. *humilis* (Pax et K. Hoffm.) W. W. Sm. et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 41 (1928), and in Journ. Roy. Hort. Soc., liv, 30 (1929).

This plant was collected in 1914 by Dr. Limpricht not far from Dawo, N.W. of Tatsienlu, growing on granite rocks of the northern precipices of Dshara at 4400–4800 m. The type, *Limpricht* 1864, is in the Breslau Herbarium. The original diagnosis assigns it to kinship with *P. incisa* and *P. oresbia*. Handel-Mazzetti (*l.c.*) places it nearer *P. Souliei* but both allocations are acceptable. It differs from *P. Souliei* in the more incised leaves which are very farinose below, in the scape not exceeding the leaves, in the more deeply cut calyx and particularly in the entire lobes of the exannulate corolla. Entire corolla-lobes are not found elsewhere in the section and are reminiscent of Nivales. Smith and Forrest (*l.c.*) assessed *P. humilis* as a subspecies of *P. Souliei*, but the material now available supports specific status. Specimens obtained in 1934 from limestone rocks at 4600 m. near Dawo in advanced fruit (*H. Smith* 11691) are the only supplement to the Limpricht collections and were at first referred to *P. Souliei*. The species, which has not been in cultivation, requires further investigation in the field.

A small minutely scabrid farinose plant with a short stout rhizome, covered at the base with remains of old foliage. Leaves including the petiole 2·5 6 cm. long; lamina 7–15 mm. long, 7–12 mm. broad, ovate to triangular-orbicular, acute or obtuse at the apex, truncate to cordate at the base, irregularly crenate to incised-serrate, scabrid above, thickly covered below with white or pale yellow farina; midrib conspicuous with obscure lateral nerves; petiole 2–3 times longer than lamina, quite discrete. Scape 1·5–5 cm. tall, farinose especially towards the apex, carrying an umbel of 1–5 flowers; bracts subulate, 7–10 mm. long, farinose; pedicels 5–15 mm. long, farinose. Calyx 6–10 mm. long, campanulate to tubular-campanulate, copiously farinose within, stained with purplish-red without, prominently 5-veined, cut to two-thirds into lanceolate to oblong-lanceolate acute lobes. Corolla rosy-blue, heteromorphic, exannulate; tube cylindrical, nearly twice as long as the calyx, slightly ampliate above the insertion of the stamens; limb 1·5 cm. to almost 2 cm. across; lobes ovate to oblong, entire or occasionally faintly denticulate. Stamens, with anthers 1 mm. long, inserted slightly above the middle of the corolla-tube in thrum-eyed flowers. Short style 3 mm. long. Capsule cylindrical, as long as or just a little longer than the calyx, dehiscing by longitudinal valves.

It is thus represented in Edinburgh:—

SZECHWAN: Tchung Ku (*Limpricht*, 1778A); Taofu (Dawo), Haitzeshan (*Harry Smith*, 11691). Phot. of *co-type* in Herb. Wien (*Limpricht*, 1864).

P. incisa Franch. in Bull. Soc. Bot. Fr., xxxiii, 69 (1886); Nouv. Arch. Mus. Hist. Nat. Paris, Ser. II, x, t. 15 (1887–88); Balf. f. in Journ. Roy. Hort. Soc., xxxix, 134, 153 (1913); W. W. Sm. and Forrest, *ibid.*, liv, 30 (1929), and in Notes Roy. Bot. Gard. Edin., xvi, 41 (1928). *P. Blinii* Lév. in Le Monde des Plantes, xvii, 2 (1915). *P. florida* Balf. f. et Forrest in Notes Roy. Bot. Gard. Edin., ix, 16 (1915); Forrest in Journ. Roy. Hort. Soc., xlii, 45 (1916); *ibid.*, lix, Proc., pp. xxv, xxviii (1934); Balf. f. in Gard. Chron., lvii, 207, fig. 65 (1915); Hand.-Mzt. in Symbolae Sinicae, vii, 743 (1936); Cowan in Bot. Mag., t. 8914 (1938). *P. Souliei* subsp. *florida* (Balf. f. et Forrest) W. W. Sm. et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 41 (1928), and in Journ. Roy. Hort. Soc., liv, 30 (1929). *P. pectinata* Balf. f. et Forrest in Notes Roy. Bot. Gard. Edin., xiii, 15 (1920). *P. incisa* subsp. *pectinata* (Balf. f. et Forrest) W. W. Sm. et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 41 (1928), and in Journ. Roy. Hort. Soc., liv, 30 (1929). *P. oresbia* Balf. f. in Notes Roy. Bot. Gard. Edin., ix, 32 (1915). *P. Souliei* subsp. *oresbia* (Balf. f.) W. W. Sm. et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 41 (1928), and in Journ. Roy. Hort. Soc., liv, 30 (1929).

The type material of this species in the Paris Herbarium was collected by Père David in 1869 in alpine woods in the district of Mupin, N.E. of Tatsienlu. It is now known to be fairly prevalent in Western Szechwan and to extend into N.W. and N.E. Yunnan with an altitudinal range of 3200–4500 m. It occurs on ledges of cliffs on stony slopes and meadows as well as in forests. Earlier views of its position in the genus and its relationship with *P. Souliei* are discussed in the introduction. Franchet's diagnosis and figure represent one phase of the plant, efarinose but minutely scabrid. Consequently the ample material which became available during the last thirty years did not appear to coincide with the original description in all instances and several specific names were published which must now be regarded as synonyms. The species varies much in the incidence of farina and in the degree of incision on the leaves. Very farinose forms occur throughout the area of distribution and are equivalent to what was described as *P. Blinii*. The efarinose *P. pectinata* cannot be separated from typical *P. incisa*. There is something to be said in favour of giving *P. florida* at least varietal status. It is a more elate plant and sometimes shows in its leaf-shape an approach to *P. Souliei*, as can be seen in Bot. Mag.

(*l.c.*). It flowered at Edinburgh from Forrest's seeds in 1915 and persisted until 1939. The marginal indentation of its leaves, in the wild as in cultivation, forms a gradual series, precluding any satisfactory differentiation from *P. incisa.*

A scabrid, farinose or efarinose plant with a fairly stout rhizome. Leaves including the petiole 1·5-10 cm. long; lamina 0·7–3 cm. long, 0·5-3 cm. broad, ovate or suborbicular to oblong, rounded at the apex, shortly cuneate to truncate or cordate at the base, dentate or incised-dentate to bidentate-lobulate at the margin, scabrid above, white farinose below, very occasionally slightly yellow farinose, or efarinose and then with a covering of farini-potent glands: midrib conspicuous with slender parallel lateral nerves; petiole 1–3 times the lamina, slender and discrete, very narrowly winged. Scape 5–45 cm. tall, minutely puberulous, often with a little white farina towards the apex, carrying an umbel of 2-10 flowers; bracts 5–8 mm. long, 1–2 mm. broad, lanceolate to linear-lanceolate, acute or obtuse, slightly scabrid, farinose or efarinose but with potentially farinose glands; pedicels 2–8 mm. long, more or less erect, farinose. Calyx 4–6 mm. long, campanulate to tubular-campanulate, farinose especially within, prominently 5-ribbed, cut to the middle or slightly beyond into lanceolate acute or obtuse teeth. Corolla soft purplish-rose to bluish-purple, occasionally white, heteromorphic, exannulate or occasionally annulate: tube cylindrical, at least twice as long as calyx; limb 1–2 cm. across, more or less concave with overlapping broadly obovate conspicuously emarginate lobes, sometimes with an apiculus in the sinus. Stamens, with anthers about 1·5 mm. long, inserted at apex of tube in thrum-eyed flowers and at base in pin-eyed. Long style equalling corolla-tube; short style 1-2 mm. long. Capsule cylindrical, included in calyx, dehiscing at apex by 5 valves. Seeds as in *P. rupicola.*

It is thus represented in the Edinburgh Herbarium:—

S.W. SZECHWAN: Near Tatsienlu (*Pratt*, 31); (*Cunningham*, 358, 632); (*McLaren's Collector*, 5, 242); between Jedo and Tatsienlu (*Cunningham*, 542, 543, 544); Jedo (*C.* 549); Gomba La, Tatsienlu (*Harry Smith*, 10677); Minya country, S. of Tatsienlu (*Rock*, 17474); Minya Konka Snow Range (*R.* 17666, 16311, 16330); Mupin (*Wilson*, 1085); Wa Shan (*W.* 3154); Pao-hsing Hsien (*Yü*, 2218); Muti Konka, Muli (*R.* 23726); Mount Gibboh, S. of Muli Gomba (*R.* 24169, 24187); Mountains of Kulu (*R.* 16455, 18105); Mountains between the Litang and Yalung Rivers (*R.* 16661, 16717); Dzampe Sheren (*R.* 24326); between Hokio and Litang

(*Cunningham*, 577); Mountains around Muli (*Forrest*, 16805—*type* of *P. pectinata*, 20438, 28389); Mountains E. of Yungning (*F.* 21266).

E. YUNNAN: Summit of Io-Chan (*E. E. Maire*—*type* of *P. Blinii* and *type* of *P. oresbia*).

The following in the Herbarium represent the variety or form known as *P. florida*:—

N.W. YUNNAN: Mountains N.E. of the Yangtze bend (*Forrest*, 10484—*type* of *P. florida*, 10485—albino form, 10486); Chungtien Plateau (*F.* 10774, 12630, 16443); Mountains N.W. of Chien-Chuan (*F.* 12646); Goo-du Shan (*F.* 20539 *pro parte*); Haba Shan (*F.* 30208); Yungling (*F.* 30275); Shui mun Kai (*F.* 30216); Labo Shan (*F.* 30308, 30312); near Yungning (*Hand.-Mzt.*, 7127); without precise locality (*F.* 11193, 17009, 22442, 28831, 29200, 29233).

S.W. SZECHWAN: Mountains E. of Yungning (*F.* 21234); Yenching, N. of Muli (*F.* 30281); Yingba Shan, Yungning to Muli (*F.* 30242).

P. longipinnatifida Chen in Bull. Fan Mem. Inst. Biol., Bot. Ser., ix, No. 5, 300 (1939).

This recently described species is known to us only from the diagnosis and from a pen-and-ink drawing kindly furnished by Mr. Chen. He considers the plant to be closely related to *P. incisa* but differing in the longer pinnatifid leaves, in their membranous texture, and in the smaller tubular corolla. It comes from N.W. of Wa-Erh-Dje, in the Muli district of Szechwan, where it was found by T. T. Yü in 1937, growing in woods at 2800 m. The Muli territory has been extensively explored by Forrest, Ward, Handel-Mazzetti and also Rock, but there is nothing in their collections which corresponds to this plant, stated by its collector to be rare. The form of the leaves appears to indicate close proximity to *P. incisa* but they are longer and very deeply cut. These foliage characters suggest a gross state of *P. incisa*, but the very small corolla-lobes are diagnostic and have no parallel in the other species of the section. A definite assessment of the position of the species is precluded by lack of material.

A farinose plant, reaching 20 cm. in height. Leaves including the petiole 5–9 cm. long, 1–2 cm. broad; blade in its general outline narrow-oblanceolate or ovate-lanceolate to oblong, but very deeply pinnatifid into 7–9 pairs of segments (which are narrow-oblong, acute, 3–8 mm. long, 2–3 mm. broad), furnished with an elongate terminal segment, of membranous texture, glabrous or slightly farinose above, presumably white-farinose below; petiole subequal to the blade and clearly defined. Scape 15–20 cm. high, filiform, 4–5-flowered in a compact umbel, slightly farinose; bracts 2–6 mm. long, linear to narrow-oblong, sparingly farinose; pedicels 2 mm. long, white-farinose. Calyx about 5 mm. long, narrow-oblong, greenish, farinose, cut to the middle into linear-lanceolate lobes. Corolla infundibular, light purple; tube about 1 cm. long, cylindric; lobes about 2 mm. long, emarginate. Stamens in long-styled flowers inserted at middle of tube. (Above description based on original diagnosis and figure.)

The type is in the Yunnan Botanical Institute Herbarium and the representation at Edinburgh is confined to a figure:—

SZECHWAN: Muli district (*Yü* 6146—fig. of *type*).

P. rupicola Balf. f. et Forrest in Notes Roy. Bot. Gard. Edin., ix, 41 (1915); W. W. Sm. and Forrest, *ibid.*, xvi, 41 (1928), and in Journ. Roy. Hort. Soc., liv, 30, fig. 28 (1929); Bruun, Cytological Studies in Primula, 48, 128 (1932).

This species is recorded only from the N.W. corner of Yunnan where it was found by Forrest in 1913, growing on ledges of cliffs, boulders and stony pasture at 4000 m. It is allied without doubt to *P. Souliei* and *P. incisa*, but differs from both in the shape of the leaves which have long decurrent blades and thus a much winged and less discrete petiole. It flowered in cultivation in 1921 from Forrest's seeds and persisted until 1938. It is the only member of the section which has been examined cytologically (Bruun, *l.c.*).

A scabrid yellow-farinose plant with a stout rhizome, clothed at the base with the numerous remains of old foliage. Leaves including the petiole 1–10 cm. long, 0·5–2 cm. broad, oblong-lanceolate or oblanceolate to obovate or spathulate, rounded or obtuse at the apex, tapering into the membranously winged petiole more or less equalling the blade, deeply and irregularly dentate at the margin, copiously scabrid-pubescent above, yellow-farinose below; midrib conspicuous with 5–6 pairs of lateral nerves sometimes almost hidden by the farina. Scape up to 12 cm. tall, more or less scabrid, farinose especially towards the apex, carrying an umbel of 2–8 flowers; bracts 3–12 mm. long, linear to linear-subulate, scabrid-pubescent and slightly farinose; pedicels 3–25 mm. long, usually twice the bracts, slender, scabrid and farinose. Calyx 7–12 mm. long, campanulate to tubular-campanulate, prominently 5-nerved, slightly farinose without, more copiously within, divided to the middle or nearly so into lanceolate acute lobes. Corolla rose with a yellow or greenish eye, annulate, heteromorphic; tube narrowly-cylindrical, slightly ampliate above the insertion of the stamens, about twice as long as the calyx, pubescent within; limb 1·5–2 cm. across with patent or semi-patent oblong-obovate to obcordate deeply emarginate lobes. Stamens, with anthers about 1·5 mm. long, inserted in the lower half of the corolla-tube in pin-eyed flowers and slightly above the middle in thrum-eyed. Long style as long as or a little longer than calyx; short style half as long as calyx. Capsule oblong, as long as calyx or barely so, dehiscing by 5 longitudinal valves. Seeds about 0·6 mm. in diameter, irregularly quadrate, vesicular-surfaced.

It is thus represented:—

YUNNAN: Mountains in the N.E. of the Yangtze bend (*Forrest*, 10338—*type*); Mountains of the Chungtien plateau (*F.* 12624); Labo Shan (*F.* 30309); E. of Yungling (*F.* 30252).

P. rupicola Balf. f. et Forrest var. **albicolor** W. W. Sm. et Fletcher.* Var. nov.

This variety is confined to S.W. Szechwan, occupying a different area from the type but still adjacent. It was first collected by Forrest in 1922 in the Muli district, growing on shady ledges of limestone cliffs at 4300 m. It differs in its white farina and exannulate corolla. These characters on occasion serve in the genus as indications of specific difference but are not always reliable, and are here regarded as signifying only varietal divergence.

It is thus represented:—

SZECHWAN: Mountains N.E. of Muli (*Forrest*, 21336—*type*): sine loc. (*F.* 30256); Mount Mitzuga, West of Muli Gomba, Muli (*Rock*, 16056); Mountain between Litang and Yalung Rivers, Muli (*R.* 16705); Dzampe Sheren, E. Muli (*R.* 23764); Mount Konka, Risonquemba, Konkaling (*R.* 16333); sine loc. (*Forrest*, 28532—efarinose form).

P. Souliei Franch. in Journ. de Bot., ix, 450 (1895); Pax in Engl. Pflanzenr. Primulaceae, 112 (1905); Balf. f. in Journ. Roy. Hort. Soc., xxxix, 138, 157 (1913); Hand.-Mzt., *ibid.*, liv, 53 (1929); W. W. Sm. and Forrest, *ibid.*, liv, 30 (1929), and in Notes Roy. Bot. Gard. Edin., xvi, 41 (1928).

This species was first collected in Western Szechwan on the mountains of Tchito near Tatsienlu by Père Soulié when he was stationed at that city between 1886 and 1891. The type specimen, *Soulié* 383, is in the Paris Herbarium. Although several botanists have since collected in the territory around Tatsienlu, very little additional material of *P. Souliei* has been secured during the intervening years and a complete analysis is not yet possible. Rock records it as growing on cliffs at 4120 m. Its position in the genus has been variously assessed: see introduction p. 459. It differs from its ally *P. incisa* in the much less indented leaf, in the looser inflorescence, in the longer pedicels, in the larger calyx and in the annulate corolla with possibly flatter limb. It has not been in cultivation.

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* Varietas haec szechuanica foliis subtus albo-farinosis, corollae tubo exannulato intus magis pubescente a typo yunnanensi divergit.

An efarinose or farinose minutely scabrid plant with a short comparatively stout rootstock. Leaves including the petiole 2–6 cm. long; lamina 1–2 cm. long, 0·5–1·5 cm. broad, ovate, obtuse or rounded at the apex, slightly tapering or truncate or somewhat cordate at the base, crenate, often irregularly so, at the margin, scabrid on both surfaces particularly on the upper, efarinose or white-farinose below; midrib conspicuous with slender lateral nerves; petiole as long as or up to three times longer than the lamina, well defined and scarcely winged, slightly scabrid. Scape 5–12 cm. tall, slender, slightly scabrid, efarinose or with a touch of farina at the apex, carrying a single flower or an umbel of 2–8 flowers; bracts subulate to linear-lanceolate, 5–9 mm. long, finely scabrid and sometimes slightly swollen at the base; pedicels 0·5–1·5 cm. long and usually twice the bracts, scabrid and sometimes with a little farina. Calyx tubular-campanulate, 6–8 mm. long, somewhat pergamentaceous, divided for a third to a half into linear-lanceolate to lanceolate acute or obtuse teeth, prominently 5-nerved and often deeply stained with purple, efarinose or farinose. Corolla purplish-violet, annulate, heteromorphic; tube cylindrical about 1 cm. long, slightly puberulent; limb 1–1·8 cm. across, with obcordate deeply emarginate lobes. Stamens, with anthers nearly 2 mm. long, inserted near the middle of the corolla-tube in thrum-eyed flowers and towards the base in pin-eyed. Long style as long as calyx or a little longer; short style just exceeding 1 mm. Capsule (ex Franchet) ovate, shorter than calyx.

It is represented in Edinburgh by the following:—

Szechwan: Lat Sa (*Soulié*, 2920). Grasslands of Yulong-Hsi, Minya Country, south of Tatsienlu (*Rock*, 17499).

P. Souliei Franch. subsp. **Legendrei** (Bonati) W. W. Sm. et Forrest in Notes Roy. Bot. Gard. Edin., xvi, 41 (1928), and in Journ.

Roy. Hort. Soc., liv, 30 (1929). *P. Legendrei* Bonati in Bull. Soc. Bot. Genève, v, 297, cum fig. (1913). *P. parvula* Pax et K. Hoffm. in Fedde Rep. Nov. Spec., xvii, 93 (1921); Hand.-Mzt., Medd. Göteb. Bot. Trädg., ii, 110 (1925–26).

The somewhat meagre material on which the original diagnosis was based was collected by Dr. Legendre in 1908 on mountains in Western Szechwan called Oua-Pao-Shan at 3000 m. He has recorded it as fairly common on sandstone or grit. Bonati placed his species in section Sinenses—an allocation far from the mark. The type is in the Paris Herbarium, a single specimen which is figured by Bonati. Examination of the type indicates clearly a near approach to *P. Souliei* from which it differs to some degree in the longer and slenderer pedicels, in the smaller and more sharply toothed calyx, and possibly in the exannulate corolla. Material received in 1937 from near Tatsienlu (*McLaren's Collector* 16) has all the features of Legendre's plant except that it is more or less farinose—almost certainly a negligible distinction. As for *P. parvula*, Dr. Handel-Mazzetti (*l.c.*) after examination of the original specimens has stated that it has nothing to do with *P. Clarkei* with which it was first associated, that it is very near *P. Souliei* and with further material is likely to prove identical with that species. What we have seen of the type is in confirmation of that view. *P. parvula* is here provisionally included in the subspecies. To rank *P. Legendrei* as a subspecies is perhaps more than it merits, for it may not be more than a slender expression of *P. Souliei*. The available data must be supplemented by further observations in the field.

A minutely scabrid efarinose or farinose plant. Leaves including the petiole up to 5 cm. long; lamina 1–2·5 cm. long, 1–2 cm. broad, ovate, acute or obtuse or rounded at the apex, truncate to cordate at the base, irregularly crenate to incised-serrate at the margin, membraneous in texture, scabrid above, white farinose below or there covered with potentially farinose glands; petiole quite discrete, one to two times as long as the lamina. Scape 6–13 cm. tall with 1–9 flowers; bracts linear-lanceolate to subulate, 3–6 mm. long; pedicels very slender, 1–2·5 cm. long. Calyx campanulate, 4–6 mm. long, prominently 5-veined, farinose within and without, especially within, split to the middle into lanceolate acute or obtuse teeth. Corolla reddish-violet, exannulate, heteromorphic; tube cylindrical, slightly ampliate above the insertion of the stamens, about twice as long as the calyx; limb 1–2 cm. across with obcordate deeply emarginate lobes. Stamens, with anthers 1·5 mm. long, inserted as in *P. Souliei*. Long style 6 mm. long; short style 1 mm. long.

It is thus represented in Edinburgh:—

SZECHWAN: Tatsienlu (*McLaren's Collector*, 16); phot. of *type* (*Legendre*); Kanse-Dege (*Limpricht*, 2124—fragment of *type* of *P. parvula*; phot. of *co-type* in Herb. Wien).

P. xanthopa Balf. f. et Cooper in Notes Roy. Bot. Gard. Edin., ix, 204 (1916); W. W. Sm. and Forrest, *ibid.*, 41 (1928); Cooper, *ibid.*, xviii, 82, pl. 238, fig. 5 (1933); W. W. Sm. and Forrest in Journ. Roy. Hort. Soc., liv, 30 (1929).

This species is known only from a pass called the Dongo La, in the Kurted district of E. Bhutan, where it was found by Cooper in 1915, growing on mossy rocks under Abies forest at 4000 m. Ludlow and Sherriff collected it again in 1933 in the vicinity of the same pass. Its sectional position is somewhat uncertain. The original diagnosis associated it with *P. yunnanensis* but called attention to the deeply incised leaves and the long petioles. These characters induced Smith and Forrest (*l.c.*) to transfer it to section Souliei, in proximity to *P. incisa*. Its leaves, however, fail to show the scabridity which is prevalent in the section. It has not been in cultivation and cytological data are not available as criteria. The description given of the seeds (Balfour, *l.c.*) favours kinship with Souliei.

A farinose non-scabrid plant with a long thin rhizome and usually clothed at the base with the withered remains of old foliage. Leaves including the petiole 2–9 cm. long, 0·5–2 cm. broad; lamina oblong or elliptic or obovate, rounded at the apex but there and along most of the margin very deeply incised-dentate the teeth being acuminate and often apiculate, entire towards the decurrent base, of membranous texture, glabrous and efarinose above or with a thin covering of farini-potent glands and occasionally a little farina, thickly covered below with golden yellow farina; midrib conspicuous below with very slender lateral nerves; petiole winged, as long as the blade or up to twice as long, broad and sheathing at the base, yellow-farinose. Scape 5–10 cm. tall, slender, farinose towards the apex, carrying 1–3 flowers; bracts markedly unequal, oblong to slightly oblanceolate, 7 mm. long and nearly 2 mm. broad, or linear-lanceolate and about 4 mm. long, in all cases more or less farinose; pedicels up to 1 cm. long, suberect, yellow-farinose. Calyx 4–5 mm. long, campanulate, farinose within and without, cut to about two-thirds into oblong-ovate obtuse or acute teeth, each with one prominent nerve. Corolla purplish-pink with a yellow eye, exannulate, heteromorphic; tube cylindrical, ampliate above the insertion of the stamens, about 1 cm. long; limb 1–1·5 cm. across with obovate emarginate lobes. Stamens, with anthers barely 1 mm. long, inserted near middle of tube in pin-eyed flowers, towards apex in thrum-eyed. Long style almost equalling tube; short style as long as calyx. Capsule oblong, almost 5 mm. long, included in calyx. Seeds rather flat, 0·75 mm. long, vesicular-surfaced.

The species is thus represented in Edinburgh:—

BHUTAN: Dongo La, Kurted (*Cooper*, 4393—*type*, 4977); (*Ludlow and Sherriff*, 329).

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THE GENUS PRIMULA: SECTION ROTUNDIFOLIA Balf. fil.

By W. WRIGHT SMITH and H. R. FLETCHER.

(Read 17th June 1943.)

This small section cannot be sharply differentiated from the large aggregate of the Nivales and could with a measure of justification be included within it. Most of the components by reason of their long slender discrete petioles and more or less rounded leaf-blades with cordate base present, however, a facies which appears alien to Nivales. By no author has any one of the species except *P. tzetsouensis* been referred to Nivales and the section can meanwhile be upheld. But there is an obvious link between *P. obtusifolia*, a Nivalid, and *P. Caveana* and *P. consocia* of this section. Kinship with Nivales is clearly shown in the structure of both calyx and corolla, in the capsule and seeds and also in the cytology (Bruun) (1), though only *P. Gambeliana* has been examined. The sectional name was first given in 1916 when Balfour (2) described *P. cardiophylla* and *P. Littledalei*, associating them with *P. rotundifolia* Wall. (nec Pall.). No diagnosis of the section was published, but evidently the Wallichian plant was intended to be the representative species. In 1889 Pax (3) had included *P. rotundifolia* in his section Cordifoliae along with *P. reticulata*, *P. grandis*, and *P. pulchra*—all with a certain similarity in leaf outline but otherwise very diverse and referable to four separate sections. In 1905 Pax (4), when dealing again with his section, left out *P. grandis* and restricted the content to five Himalayan members. As Pax from this still mixed assemblage did not indicate the leading species, Balfour's somewhat incidental suggestion of a sectional name for *P. rotundifolia* and its two new allies was adopted by Smith and Forrest (5). Their general description of the section is still adequate and the specific names cited are all within the section, though some are now known to be synonyms. Since 1928 *P. Barnardoana* and *P. consocia* have been added, and *P. Caveana* (with its synonyms *P. cana* and *P. Younghusbandiana*) has been transferred to it in this review from the now disintegrated section Obtusifolia.

P. rotundifolia and *P. Barnardoana* are still in cultivation but very uncommon. *P. Baileyana*, *P. Caveana*, and *P. Gambeliana* have flowered in gardens but we find no record later than 1941.

TRANS. BOT. SOC. EDIN., VOL. XXXIII. PT. IV., 1943.

The members of the section are not easily retained. Seeds usually germinate well, but the resulting plants rarely produce ripe capsules and do not as a rule persist beyond a few years.

References.

(1) Bruun, Cytological Studies in Primula, 83 (1932).
(2) Balfour, Notes Roy. Bot. Gard. Edin., ix, 152, 179 (1916).
(3) Pax, Engler's Bot. Jahrb., x, 215 (1889).
(4) Pax, Engler's Pflanzenr. Primulaceae, 120 (1905).
(5) Smith and Forrest, Notes Roy. Bot. Gard. Edin., xvi, 38 (1928). and in Journ. Roy. Hort. Soc., liv, 37 (1929).

KEY TO THE SPECIES.

A. Flowers mauve to purple or violet:
B. Leaves cordate or truncate at base:
C. Cor. lobes entire or crenulate:
D. Inflorescence very farinose:
E. Farina yellow; large resting bud; capsule nearly twice as long as calyx, lateral veins ± pinnate (Nepal, Sikkim) *rotundifolia*
EE. Farina white; elongate rhizome; capsule at most subequal to calyx, lateral veins ± basal (Tibet) . . . . *Littledalei*
DD. Inflorescence efarinose or subefarinose; rootstock slender (S.E. Tibet) . . . . *consocia*
CC. Cor. lobes distinctly emarginate:
D. Leaves ovate, efarinose; inflor. efarinose; capsule twice as long as calyx . . . . *Gambeliana*
DD. Leaves orbicular, farinose; inflor. farinose; capsule barely as long as calyx . . . . *Baileyana*
BB. Leaves decurrent; capsule subglobose, ± included in calyx . *Caveana*
AA. Flowers yellow:
B. Leaf-blade 1·5–3 cm., dentate, apex ± acute (Szechwan) . *tzetsouensis*
BB. Leaf-blade 1·5–7 cm., crenate, apex rounded (Tibet) . *Barnardoana*

P. Baileyana Ward in Notes Roy. Bot. Gard. Edin., xv, 82, 94 (1926); W. W. Sm. and Forrest, *ibid.*, xvi, 38 (1928); Gard. Chron., lxxix, 200, fig. 100 (1926); Journ. Roy. Hort. Soc., lii, 22, Proc., p. xlvi (1927); *ibid.*, liv, 37, 63, 74 (1929); Stapf in Bot. Mag., t. 9189 (1930).

This species is known only from S.E. Tibet where it was first found by Ward in 1924 at 4600–5000 m. It grows on cliffs and grassy slopes among dwarf Rhododendrons, on boulder screes and in sheltered gullies. The original diagnosis associates it quite aptly with *P. Littledalei* and *P. rotundifolia.* From the latter it diverges in the much slenderer habit, in the snow-white farina, in the smaller leaves with truncate base and different venation, in the calyx and in the emarginate corolla-lobes; from the former in the shape and texture of the leaves, in the thin wiry petioles and scape, in the calyx and corolla-lobes. It flowered in cultivation at Kew and Edinburgh in 1926 and persisted at Edinburgh until 1941.

A glabrous farinose perennial with a short rhizome and long fibrous roots. Leaves forming an open rosette, including the petiole 2–12 cm. long; lamina 0·5–4 cm. broad and long, orbicular or ovate-orbicular to reniform, rounded at the apex, subtruncate or slightly cordate at the base, crenate to crenate-dentate, glabrous, thickly covered with pure white farina below; midrib and 4–7 pairs of lateral nerves prominent; petiole 1–8 cm. long, thin, wiry, farinose. Scapes 1–3, slender, 3–18 cm. tall, slightly farinose, carrying an umbel of 1–7 flowers; bracts 4–12 mm. long, linear to lanceolate-linear, green or tinged with purple, copiously farinose within; pedicels 3–20 mm. long, erect, farinose. Calyx 6–9 mm. long, tubular to tubular-campanulate, green or deeply purple-tinged, farinose both within and without, with 5 conspicuous veins, cut to one-half or two-thirds into lanceolate-oblong to linear acute or obtuse lobes. Corolla about 2 cm. long, 1·2–2 cm. broad, pale violet to violet with a white or pale yellow eye, annulate or ex-annulate, heteromorphic; tube cylindrical, about twice as long as calyx, slightly ampliate above insertion of stamens; limb with broad obcordate emarginate lobes. Stamens, with anthers 1–1·5 mm. long, inserted at apex of corolla-tube in thrum-eyed flowers, at middle in pin-eyed. Long style as long as or almost as long as corolla-tube; short style equalling calyx. Capsule ovoid to oblong, barely as long as calyx, dehiscing from the apex by longitudinal valves. Seeds 0·5 mm. in diameter, quadrate or irregularly rounded, vesicular-surfaced.

The representation at Edinburgh is:—

S.E. Tibet: Nambu La (*Ward*, 6093—*co-type*); Nam La (*W*. 5985); Tse La (*W*. 12250); Go Nyi Re, Paka Phu Chu (*Ludlow, Sherriff and Taylor*, 5887); Mira La, Nyang Chu (*L., S. and T.*, 6034); Kyabden, Nyang Chu (*L., S. and T.*, 6188); Pasum La, Drukla Chu (*L., S. and T.*, 6882, 6902); sine loc. (*L., S. and T.*, 4604, 4604a, 5026, 5026a, 6191).

P. Barnardoana W. W. Sm. et Ward in Notes Roy. Bot. Gard. Edin., xix, 167 (1936); Ward in Quart. Bull. Alp. Gard. Soc., iv, 249 (1936).

The first specimens of this species were secured by Ward in 1935 in Southern Tibet at 4000–4300 m. The type, *Ward* 11616, is in the British Museum Herbarium. The plant grows among and beneath Rhododendrons, sometimes in Conifer forest and on open cliff ledges. The distinguishing features in this Tibetan material are the broadly ovate leaves with cordate base, pale yellow farinose below, the far exserted tube of the yellow corolla and the very elongate capsules. The Szechwan species, *P. tzetsouensis*, also has yellow flowers but very small leaves with acute apex and dentate margin. It may prove to be a near ally but is incompletely known. In its general aspect *P. Barnardoana* invites comparison also with *P. Gambeliana* which is almost efarinose and has purplish flowers. In 1937 Ludlow and Sherriff made several gatherings in Central Bhutan which were at first referred (*in scheda*) to the Sikkim *P. elongata*, but are now seen to come very near to *P. Barnardoana* and may well represent somewhat divergent states of it. In this Bhutan material some sheets are in accord with the Tibetan type; some show leaves with somewhat decurrent blades and winged petioles, some are efarinose except for the resting bud. The general evidence is, however, in favour of regarding them all as conspecific. This variability in *P. Barnardoana* as to leaf-shape suggests that no sharp line can be drawn between Rotundifolia and Nivales. Moreover, when the leaves are subdecurrent, *P. Barnardoana* shows a very striking resemblance to *P. strumosa* of the section Petiolares and discrimination is not easy unless the completely diagnostic capsule is available. The species was for a brief period in cultivation at Edinburgh, flowered in 1940 but did not persist. It was, however, recorded in 1943 in at least one private garden.

A more or less farinose plant with a short rhizome, girt at the base with farinose imbricate ovate bud-scales. Leaves including the petiole 3–18 cm. long; lamina 1·5-7 cm. long, 1–4·5 cm. broad, ovate, rounded or obtuse at the apex, cordate at the base but occasionally rounded or even slightly decurrent, crenate to crenate-dentate, efarinose but with farini-potent glands below or there thickly coated with cream farina; midrib prominent, with 5–10 pairs of lateral nerves; petiole 1–2 times the lamina, membranously winged, sheathing at base. Scape 10–40 cm. tall, with potentially farinose glands or even a little farina at apex, carrying an umbel of 3–7 flowers, or occasionally two superposed umbels; bracts 3–10 mm. long, lanceolate, acuminate, with a conspicuous midrib, glandular or farinose; pedicels 5–15 mm. long, in fruit up to 40 mm., stout, glandular or farinose. Calyx 7–10 mm. long, tubular, densely farinose or with potentially farinose glands, conspicuously 5-ribbed, cut almost to two-thirds into lanceolate acute lobes. Corolla bright yellow or orange or glistening greenish-yellow with a darker yellow eye, annulate, sometimes only faintly so, heteromorphic; tube cylindrical, ampliate above insertion of stamens, twice as long as calyx; limb with obovate entire or slightly emarginate lobes.

Stamens, with anthers 2·5 mm. long, inserted at apex of corolla-tube in thrum-eyed flowers, at middle in pin-eyed. Long style as long as corolla-tube or even slightly exserted. Short style more or less equalling calyx. Capsule 2–2·3 cm. long, 5 mm. broad, cylindrical, straw-coloured, dehiscing by longitudinal valves.

In Edinburgh are the following collections:—

S. Tibet: Luguthang, Mönyul (*Ward*, 11616 *–co-type*).

C. Bhutan: Dungshinggang (*Ludlow and Sherriff*, 3264); Phobsikha (*L. and S.*, 3060, 3097); Rinchen Chu (*L. and S.*, 3393).

P. Caveana W. W. Sm. in Rec. Bot. Surv. Ind., iv, 218 (1911); Craib in Journ. Roy. Hort. Soc., xxxix, 189 (1913); W. W. Sm. and Forrest, *ibid.*, liv, 38 (1929), and in Notes Roy. Bot. Gard. Edin., xvi, 34 (1928). *P. cana* Balf. f. et Cave in Notes Roy. Bot. Gard. Edin., ix, 151 (1916). *P. Younghusbandiana* Balf. f. in Kew Bull., 152 (1922); W. W. Sm. and Forrest in Notes Roy. Bot. Gard. Edin., xvi, 34 (1928), and in Journ. Roy. Hort. Soc., liv, 38 (1929).

The type specimens of this species were collected in 1909 by Smith and Cave in the extreme N.W. of Sikkim in the district known as Llonakh at 4800–5000 m. This area has a climate similar to the adjoining parts of Tibet -much drier than the rest of Sikkim. Earlier specimens in advanced fruit were secured in 1882 in Tibet by King's collector and in 1903 by Younghusband in Llonakh and by Prain near the Tibetan town of Khambajong. It grows in sheltered rock-crevices under somewhat arid conditions and thus in its general aspect resembles *P. Littledalei*. It has the same stout persistent rhizome enveloped in old leaves and wiry petioles and is profusely farinose. It differs from that species and from other members of the section in its decurrent lamina and less discrete winged petiole. Although retained here in Rotundifolia by reason of its obvious association with the species of that section, it is not far removed from the N.W. Himalayan *P. obtusifolia*, one of the Nivales. It forms a link between two sections not fundamentally different and could be placed in either. Further material received during the last twenty years from Bhutan and Tibet is in conformity with the Llonakh specimens and serves to show that *P. cana* and *P. Younghusbandiana* can both be safely regarded as synonyms. The latter comes from the Kharta Valley near Mt. Everest and is recorded from a height of 6000 m. *P. Caveana* is obdurate in culture, but it has been flowered at least once in this country—by Mrs. Shaw-Mackenzie in Easter Ross in 1939.

A farinose plant with a stout rhizome and long fibrous roots, clothed at the base with numerous twisted remains of old foliage and at times with a few imbricate bud-scales. Leaves including the petiole 2–15 cm. long; lamina 1–8 cm. long, 1–2·5 cm. broad, oblong to elliptic or obovate to suborbicular, rounded at the apex, abruptly or gradually tapering at the base, deeply dentate, puberulous above, densely white-farinose below; midrib conspicuous with the fine lateral nerves and reticulation more or less obscured by farina below; petiole subequal to or even up to 3 times longer than lamina, membranously winged, broad and sheathing at the base. Scape 3–12 cm. tall, solitary or several, usually sturdy, slightly farinose, carrying an umbel of 1–9 fragrant flowers; bracts 7–15 mm. long, linear to linear-lanceolate, occasionally narrowly oblanceolate, farinose; pedicels 1–2 cm. long at flowering time, up to 4 cm. in fruit, farinose. Calyx 5–10 mm. long, tubular to tubular-campanulate, farinose both within and without, cleft for two-thirds or even more into linear-lanceolate to oblong lobes, acute or obtuse and occasionally toothed at the apex. Corolla 1–2·5 cm. long and broad, pale purple with a lemon-yellow eye, annulate, heteromorphic; tube cylindrical, 1–2 times the calyx, ampliate above insertion of stamens; limb with broadly obovate, entire or crenulate or erose lobes. Stamens, with anthers 1·5 mm. long, inserted at apex of corolla-tube, with the tips reaching the annulus in thrum-eyed flowers, in lower half of tube in pin-eyed. Long style reaching the annulus; short style half as long as corolla-tube. Capsule globular-ovoid, included in the calyx, dehiscing by longitudinal valves. Seeds 0·75 mm. in diameter, irregularly quadrate, markedly vesicular-surfaced.

In the Edinburgh Herbarium are the following:—

SIKKIM: Lhonakh (*Smith and Cave*, 1810—*co-type*, 2111); (*Younghusband*, 188); sine loc. (*Cave*, 1423—*type* of *P. cana*, 1513).

S. and S.E. TIBET: Kambajong (*Prain* in 1903); Chomolari, Chumbi Valley (*Rhomoo*, 511); Pangla, Migyitun, Tsari (*Ludlow and Sherriff*, 2536, 2791); Bimbi La, Tsari (*L. and S.*, 1768); (*Ward*, 11971); Lapa, Tsari (*L. and S.*, 2162); sine loc. (*King's collector* in 1882).

BHUTAN: Champa Pumthang (*Cooper*, 4059, 4788); Changsethang, Maugde Chu (*Ludlow and Sherriff*, 3408, 3410).

P. consocia W. W. Sm. in Notes Roy. Bot. Gard. Edin., xix, 167 (1936); Ludlow in Himalayan Journal, x, 18, fig. facing p. 12 (1938).

P. consocia was found by Ward in southern Tibet in 1935 at 5000–5300 m. growing in crevices of slate cliffs and on the adjacent screes. Nearest of kin are *P. rotundifolia* and *P. Littledalei* from which it differs in the slender rootstock, in the absence of a strongly farinose resting-bud, in the leaf-shape, in the efarinose or only obscurely farinose inflorescence, and in the calyx. *P. Caveana* has a distinct leaf-shape and copious farina. The appearance of *P. consocia* suggests that its habitat is much more moist than that of *P. Littledalei* or of *P. Caveana*. But closely associated as *P. consocia* may be with *P. Littledalei*, and variable in their vegetative features as the members of this section are, environmental factors are insufficient to account for the differences noted and the available evidence is in favour of retaining a specific status for it. It has not been in cultivation. The figure in colour (Ludlow, *l.c.*) is from a photograph taken in Tibet by Major Sherriff.

A farinose or more or less efarinose plant with a short rather slender rhizome. Leaves, including the petiole, 2–10 cm. long; lamina 1–2 cm. broad and long, ovate to suborbicular, rounded at the apex, broadly cuneate or rounded to slightly cordate at the base, deeply dentate to crenate-dentate, completely efarinose but with farinipotent glands or quite conspicuously covered with white or cream farina below; midrib prominent with lateral nerves obscure below in farinose leaves; petiole 1–8 cm. long, broad and at the base markedly sheathing. Scape 2–12 cm. tall, solitary or up to 4, efarinose but with potentially farinose glands or faintly farinose, carrying an umbel of 1–8 flowers; bracts 5–10 mm. long, linear to narrowly lanceolate, green or deeply stained with purple, covered with farinipotent glands or even a little farina; pedicels 5–15 mm. long, erect. Calyx 6–9 mm. long, tubular-campanulate, dull purplish-green, slightly farinose within, usually cut to a little below the middle into oblong obtuse or occasionally acute lobes. Corolla 1·5–2 cm. long and broad, purplish-pink, with a pale lemon-orange eye, fragrant, annulate or exannulate, heteromorphic; tube cylindrical, half as long again as calyx, ampliate above insertion of stamens; limb with obovate entire or crenulate lobes. Stamens, with anthers 1·5 mm. long, inserted slightly above middle of corolla-tube in thrum-eyed flowers, in lower third in pin-eyed. Long style equalling two-thirds of corolla-tube; short style about one-third. Capsule slightly longer than calyx, dehiscing by longitudinal valves. Seeds barely 1 mm. long, irregularly quadrate or irregularly ovoid, under the lens markedly vesicular-surfaced.

The type is in the British Museum Herbarium and at Edinburgh are:—

S. TIBET: Drichung La (*Ward*, 11814—*co-type*); Le La, Chayul Charme (*Ludlow and Sherriff*, 2284).

P. Gambeliana Watt in Journ. Linn. Soc., xx, 3, t. 1 (1882); Hook. f. in Fl. Brit. Ind., iii, 483 (1882); Gard. Chron., xxi, 541, fig. 106 (1884); Pax in Engl. Bot. Jahrb., x, 216 (1889), and in Engl. Pflanzenr. Primulaceae, 122 (1905); Journ. Roy. Hort. Soc., xxxix, 189, 202, 215–7, 812, fig. 95 (1913); W. W. Sm. and Forrest in *ibid.*, liv, 38 (1929), and in Notes Roy. Bot. Gard. Edin., xvi, 38 (1928); Bruun, Cytological Studies in Primula, 83, 92, 126 (1932); Quart. Bull. Alp. Gard. Soc., iv, 281, fig. p. 280 (1936). *P. Gambleiana* Watt in Journ. Roy. Hort. Soc., xxix, 301, 321 (1904).

Sir George Watt discovered this species in full flower in the first week of June 1881, at 4500 m., above Jongri, a classic botanical area in West Sikkim. It grows usually among moss and very often in the crevices of steep wet cliffs. It is now known from over the Nepal frontier, from Bhutan and S.E. Tibet. Like *P. rotundifolia* it varies much in size according to the situation, the smallest plants bearing only a solitary flower. The fruiting stage shows a marked increase in the size of both leaf and scape. The species differs from *P. rotundifolia*, *P. Baileyana*, and *P. Littledalei* in the leaves which are ovate-cordate or ovate-oblong rather than orbicular, in the lack of farina on both leaves and inflorescence and in the elongate capsule. The resting bud has, however, densely farinose scales. The species was in cultivation at Edinburgh from 1930 until 1941. The figure which accompanies Watt's diagnosis shows the leaves more orbicular than is usual. The species was named in honour of J. S. Gamble, F.R.S., author of many publications dealing with the flora of India and of Malaya.

A perennial plant with a very short rhizome and long fibrous roots and girt at the base with a few imbricate ovate white- or yellow-farinose bud-scales. Leaves including the petiole 2–30 cm. long; lamina 1–10 cm. long, 0·5–6 cm. broad, ovate to orbicular, rounded or obtuse or acute at the apex, usually deeply cordate at the base, occasionally truncate, dentate to crenate-dentate, efarinose though sometimes with a few farini-potent glands below; midrib and lateral nerves conspicuous; petiole up to four times the length of the lamina, quite discrete, slender, sheathing at the very base. Scape 3–25 cm. long, shorter than the leaves or twice their length, efarinose, though with a few farinipotent glands, carrying usually one umbel, occasionally two, with 1–8 flowers in each; bracts 3–7 mm. long, linear-lanceolate, acute or acuminate at apex, broad at base; pedicels 2–10 mm. long, in fruit up to 2·5 cm., erect, slightly glandular. Calyx tubular-campanulate, 4–8 mm. long, efarinose, glandular, cut to two-thirds or more into lanceolate lobes each with one prominent vein and sometimes stained purple. Corolla purple-pink to violet-purple with a yellow throat, annulate, heteromorphic; tube 2–3 times longer than calyx, cylindrical, ampliate above the insertion of the stamens; limb 1·5–2·5 cm. across with broadly obcordate deeply emarginate lobes. Stamens, with anthers 1·5 mm. long, inserted near apex of corolla-tube in thrum-eyed flowers, at middle in pin-eyed. Long style reaching or almost reaching annulus; short style half length of corolla-tube. Capsule cylindrical, about twice as long as calyx dehiscing by longitudinal valves, somewhat translucent. Seeds about 1 mm. in diameter, irregularly quadrate, under lens markedly reticulate and vesicular-surfaced.

In the Edinburgh Herbarium are the following specimens:—

SIKKIM: Above Jongri (*Watt*, 5483—*type*); Jongri (*King's collector* in 1887); Ritampoo, Singalela (*Watt*, 5407); Alookthan (*Rhomoo*, 1042); Jakeyupyak (*Ribu and Rhomoo*, 5097); Mempup by Lachung (*Cooper*, 390); Megu (*Cave* in 1916 and 1922; *Ribu and Rhomoo* in 1912); Sandakphu (*Cave*, 6455; *King's collector* in 1887).

NEPAL: Pang-gi (*King's collector* in 1888).

E. BHUTAN: Sakden (*Ludlow and Sherriff*, 608, 641).

S.E. TIBET: Cho La (*L. and S.*, 874); Se La (*Ward*, 11600).

P. Littledalei Balf. f. et Watt in Notes Roy. Bot. Gard. Edin., ix, 179 (1916); W. W. Sm. and Forrest, *ibid.*, xvi, 38 (1928); Journ. Roy. Hort. Soc., lii, 23 (1927); W. W. Sm. and Forrest, *ibid.*, liv, 37 (1929); Stapf in Bot. Mag., t. 9189 (1930)—sub *P. Baileyana*; Sherriff and Taylor in Quart. Bull. Alp. Gard. Soc., vii, 238, fig. p. 239 (1939); Anley in Gard. Illust., lxii, 264, with fig. (1940); Ludlow in Himalayan Journal, xii, fig. facing p. 4 (1940).

The original material on which this species is based is unfortunately very incomplete. Walton's specimen (in Herb. Watt), collected near Lhasa in 1904, is in fruit with only one flower available. Watt states that the corolla is yellow (Balf. f. et Watt, *l.c.*), but we have seen no record to that effect by Walton. The colour (*in scheda*) suggests mauve or pink. What we have examined of

Littledale's material, collected in 1896, is all in advanced fruit. Specimens agreeing with *P. Littledalei* in habit, foliage, and inflorescence have been secured during the last twenty years from areas lying well to the south and south-east of Lhasa, but these have mauve, pink, or pale purple flowers. These are collated with *P. Littledalei* in this review, but the evidence is not quite conclusive. Plants from the environs of Lhasa would solve the problem.

P. Littledalei occurs in Tibet at 4300–5000 m., growing in the crevices of cliffs and under overhanging rocks. Well established plants show a long stout rhizome, covered with the remains of old leaves and with their withered tendril-like petioles. We learn from collectors that it affects on the whole dry situations. The nearest allies are *P. rotundifolia* and *P. consocia.* From the former it differs in the leaf-venation, in the white farina, in the smaller capsule, and also in the geographical distribution. *P. consocia* diverges in the leaf-characters, in its almost efarinose inflorescence, and in its larger capsule. *P. Littledalei* was in cultivation in 1938–40 but did not show itself tractable.

A slender farinose plant with a long stout rhizome, covered at the base with the withered and twisted remains of old foliage. Leaves, including the petiole, 3–16 cm. long; lamina 1–6 cm. long and broad, rotundate to reniform, rounded at the apex, deeply cordate to truncate at the base, strongly dentate to crenate-dentate, efarinose or with a few farini-potent glands above, conspicuously white-farinose below; midrib and the usually more or less basal lateral nerves quite prominent; petiole 1–11 cm. long, slightly farinose, broadly sheathing at the base. Scape 4–18 cm. tall, farinose towards apex, carrying an umbel of 1–15 sweet-scented erect or suberect flowers; bracts 5–15 mm. long, linear-lanceolate or lanceolate to oblanceolate, green or faintly stained with purple, farinose, slightly thickened at base and with one main nerve; pedicels 1–3 cm. long, farinose. Calyx 5–10 mm. long, campanulate, farinose within and without, cut to two-thirds or even more into lanceolate to oblong-lanceolate or occasionally elliptic, acute or obtuse lobes. Corolla 1·5–2 cm. long and broad, lilac or pale-purple with a white or yellow eye, possibly sometimes yellow, annulate, heteromorphic; tube cylindrical, a little longer than calyx or twice its length, slightly ampliate above insertion of stamens; limb with patent broadly obovate entire or crenulate lobes. Stamens, with anthers 1–1·5 mm. long, inserted slightly above middle of corolla-tube in thrum-eyed flowers, near base in pin-eyed. Long style hardly as long as the tube, short style 2–3 mm. long. Capsule ovoid, included in the calyx, dehiscing by deflexed longitudinal valves. Seeds barely 1 mm. long, irregularly quadrate or irregularly ovoid, markedly vesicular-surfaced.

The type is in the Kew Herbarium and in Edinburgh are:—

TIBET: Gooring Valley (*Littledale* in 1896—*co-type*); Lhasa (*Walton* in 1904); south of Lhasa (*Spencer Chapman*, 72); Gokar La (*Bailey* in 1924); Nam La (*Ward*, 6003); Cha La, Dongkar (*Ludlow and Sherriff*, 847); Kashong La, Chayul Chu (*L. and S.*, 2349); Langong Chu (*L., S. and Taylor*, 3892); Langong, Chiniung La (*L.. S. and T.*, 5606); Mira La, Nyang Chu (*L., S. and T.*, 6045); sine loc. (*L., S. and T.*, 5408, 5408A).

NEPAL: Dudkund at 6000 m. (*Sharma*, 503).

P. rotundifolia Wall. in Roxb. Fl. Ind. (ed. Carey), ii, 18 (1824); Tent. Fl. Nepal., 42, t. 32 (1826); Duby in DC. Prodr., viii, 41 (1844); Hook. f. in Fl. Brit. Ind., iii, 483 (1882); Gard. Chron., v, 690 (1889); Pax in Engl. Bot. Jahrb., x, 215 (1889), and in Engl. Pflanzenr. Primulaceae, 120, fig. 34B (1905); Journ. Hort., xvii, 28 (1888); *ibid.*, xxvi, 527 (1893); Journ. Roy. Hort. Soc., vii, 170, 253, 286, 288 (1886); Watt, *ibid.*, xxix, 301, 321 (1904), and *ibid.*, xxxix, 202, 215–217, fig. 102 (1913); W. W. Sm. and Forrest, *ibid.*, liv, 38 (1929); *ibid.*, lviii, Proc., p. xxvi (1933); *ibid.*, lxi, fig. 67 (1936); Tribune Hort., ix, 141 (1914); Farrer, Engl. Rock Garden, ii, 176, pl. 21 (1919); W. W. Sm. and Forrest in Notes Roy. Bot. Gard. Edin., xvi, 38 (1928); T. Hay in Gard. Chron., xci, 347, fig. 154 (1932). *P. cardiophylla* Balf. f. et W. W. Sm. in Notes Roy. Bot. Gard. Edin., ix, 152 (1916). W. W. Sm. and Forrest, *ibid.*, xvi, 37 (1928); Stapf in Bot. Mag., t. 9018 (1924); Journ. Roy. Hort. Soc., liv, 37, 74, fig. 66 (1929). *P. odontophylla* Wall. Numer. List, 7016 (1828). *P. cordifolia* Pax in Engl. Bot. Jahrb., x, 216 (1889)—non Rupr., and in Engl. Pflanzenr. Primulaceae, 122 (1905). *P. cordata* Balf. f. MSS. ex W. W. Sm. and Forrest in Notes Roy. Bot. Gard. Edin., xvi, 38 (1928), and in Journ. Roy. Hort. Soc., liv, 38 (1929).

The first material of this species was obtained by Wallich in 1821 from Gossain Than in Nepal. Wallich was not permitted by the Nepal authorities to visit the area and had to rely on the services of pilgrims who brought back specimens from the sacred place. This method of collecting did not favour quality and many Wallichian types are far from satisfactory. His diagnosis and figure are, however, very adequate but give the impression of a somewhat slender plant; this would be in keeping with the elevation of over 5000 m. for Gossain Than. For many years no more material came from Nepal, but on the Sikkim side of the frontier at 4000 m. more robust plants were found in 1848 by Hooker and later by several collectors. The Sikkim specimens were included by Hooker (*l.c.*, 483) in *P. rotundifolia* and the distribution extended to Kashmir. The latter statement is repeated by Pax (*l.c.*), but there is as yet no definite evidence that the species occurs to the west of Nepal. The figure given by Pax (*l.c.*, 121) is of a stout plant with superposed umbels, almost certainly of Sikkim origin. The problem is fully discussed by Balfour (*l.c.*, 152) when describing the Sikkim plant as *P. cardiophylla*. Since 1916 further collections have come to hand from Nepal and Sikkim and seeds from both areas have produced flowering plants. Our conclusion is that only one specific unit is concerned, variable in vigour, in the consistency of the leaves, in the degree of farina, and in the number of whorls arising on the scape. The distribution is restricted; in Sikkim the species is confined to the western frontier adjoining Nepal; in Nepal it is known from the region south of Mt. Everest.

P. cordifolia Pax (*l.c.*) presents the same problem. It was described from specimens collected by Schlagintweit at that part of the Sikkim frontier where later the robust form of *P. rotundifolia* was repeatedly obtained. The solitary sheet is in the Breslau herbarium, and this was seen in 1932 by one of the present authors who found it to be in exact correspondence with *P. cardiophylla*. *P. cordifolia* was stated to be efarinose; leaves without farina are of frequent occurrence in *P. rotundifolia*, and in any case the base of the scape in the type of *P. cordifolia* is clearly farinose. The latter name being preoccupied, Balfour *in scheda* suggested *P. cordata* (Smith and Forrest, *l.c.*) which also becomes a synonym. The prior use of the term *P. rotundifolia* by Pallas was known to Wallich but has no nomenclatorial status (*vide* Fernald in Rhodora, xxx. 101 (1928)).

P. Baileyana and *P. Littledalei* show a very close approach to the Wallichian species in habit but differ in the foliage and in the floral details. *P. Gambeliana* is somewhat more remote. *P. rotundifolia* has been fairly frequently in cultivation—earliest in 1866—but is difficult to retain and reluctant to seed.

A perennial with a short stout rootstock, usually girt at the base by imbricate ovate to ovate-oblong creamy-yellow farinose bud scales and sometimes by the withered remains of old foliage.

Leaves including the petiole 5–20 cm. long; lamina 2–12 cm. long and broad, cordate-reniform to cordate-orbicular, irregularly and coarsely crenate to crenate-dentate at the margin, somewhat fleshy, glabrous and with potentially farinose glands above, with copious creamy-yellow farina or often efarinose on the lower surface where midrib and pinnate lateral nerves are prominent; petiole 1–3 times as long as lamina, thick, at first farinose, broad and sheathing at base. Scape usually robust, 10–30 cm. tall, with numerous farinipotent glands and often with farina towards apex, carrying a single umbel or two superposed, with 2–16 flowers in each; bracts 5–15 mm. long, linear-subulate, copiously glandular and often farinose; pedicels 1–2 cm. long at flowering time, up to 3 cm. in fruit, glandular and farinose. Calyx 5–6 mm. long, campanulate, farinose within and without, cut almost to base into oblong-lanceolate acute or obtuse teeth, each with 3 nerves. Corolla 1·5–2 cm. long and broad, pale purplish-pink with golden-yellow eye, annulate, heteromorphic; tube cylindrical, 2–3 times the length of calyx, ampliate above insertion of stamens; limb with obovate to orbicular entire or subcrenate lobes. Stamens, with anthers 1·5 mm. long, inserted at apex of corolla-tube in thrum-eyed flowers, near middle in pin-eyed. Long style reaching annulus; short style equalling half corolla-tube. Capsule oblong, nearly 1 cm. long, dehiscing by longitudinal valves. Seeds about 0·75 mm. long, irregularly subquadrate or ovoid, markedly vesicular-surfaced.

The species is represented in the Edinburgh Herbarium by the following:—

NEPAL: Gossain Than (*Wallich*, 605—*co-type*); Rangtong (*Sharma*, 531); Tenboozey (*Lal Dhwoj*, 187); sine loc. (*Bailey*).

SIKKIM: Sandakphu (*King's collector* in 1887 and 1888); (*Rhomoo*, 2196); (*Ribu and Rhomoo* in 1912); (*Cave* in 1916, 1919, 1922); (*Watt*, 5375); (*Lace*, 2255).

P. tzetsouensis Petitm. in Bull. Herb. Boiss., viii, 366 (1908); Balf. f. in Journ. Roy. Hort. Soc., xxxix, 138, 159 (1913); Smith and Forrest, *ibid.*, liv, 38 (1929), and in Notes Roy. Bot. Gard. Edin., xvi, 38 (1928).

This species is based on material collected in 1904 by Abbé Soulié at Tze-tsoue which is near Yargong, south of Batang, in the province of Szechwan. The type, *Soulié* 3804, is in the Paris Herbarium. There is no record of a second collection of the plant. The country round Yargong is a dry rocky high-alpine area.

Petitmengin associated his species with *P. tangutica* and such a placing is not amiss. The leaves, however, are those of section Rotundifolia and indicate proximity to *P. Gambeliana* and *P. Barnardoana* which have a very similar habit. Balfour (*l.c.*) referred the species with much doubt to Sikkimensis. An examination of the type led Smith and Forrest (*l.c.*) to assign it definitely to Rotundifolia. The presence of an annulus debars it from Sikkimensis and the other characters of the corolla are entirely in favour of Nivales and Rotundifolia. The plant is not quite efarinose, as described by Petitmengin. The underside of the leaf has an obscure crustaceous farina with traces also on the inflorescence. The only other yellow-flowered species in the section is *P. Barnardoana* which has much larger leaves with rounded apex and crenate margins and is usually much more farinose. There is, however, evidence that a yellow-flowered form of *P. Littledalei* may exist, but that species is copiously farinose.

A slender almost efarinose plant with a short rhizome, long fibrous roots and girt at the base with the withered remains of old foliage. Leaves including the petiole 6·5–10 cm. long; lamina 1·5–3 cm. long, ovate to orbicular, more or less acute at apex, truncate to cordate at base, dentate or serrate-dentate, glabrous and efarinose except for traces of a crustaceous farina below; midrib distinct, with lateral nerves and nervules more or less obscure; petiole 5–7 cm. long, sheathing at base. Scape 16–20 cm. tall, efarinose or with a little crustaceous farina, carrying a 2–4-flowered umbel; bracts 5 mm. long, linear-lanceolate, acute, slightly swollen at base; pedicels 6–10 mm. long. Calyx 7–8 mm. long, tubular, minutely puberulous, cut to the middle into lanceolate acute lobes. Corolla yellow, annulate, heteromorphic; tube twice the calyx, ampliate above insertion of stamens; limb 15–17 mm. across with narrow more or less oblong entire lobes, 3–4 mm. broad. Stamens in pin-eyed flowers inserted at middle of corolla-tube. Long style as long as corolla-tube. Capsule unknown.

The species is thus represented in Edinburgh:—

W. CHINA: Tze-tsoue, Szechwan (photographs of *Soulié*, 3804—*type*).

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